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In reply refer to PJI

Dear Interested Party:

The initial distribution of the report entitled "Smolt Survival Workshop,'* (DOE/BP-35885-2, January 1990) is missing a line of text in the last paragraph of page "ix" of the Executive Summary. Enclosed is an adhesive insert containing the completed text that can be used to correct this errata.

Sincerely,

Patrick H. Poe
Workshop Project Manager

Enclosure

cc:
Mr. J. Anderson, University of Washington, Fisheries Research Institute
Mr. D. Dauble, Battelle, Pacific Northwest Laboratories
Mr. D. Neitzel, Batelle, Pacific Northwest Laboratories

SMOLT SURVIVAL WORKSHOP

Proceedings of a Workshop
held at
University of Washington Laboratory
Friday Harbor, Washington
February 1-3, 1989

By

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Prepared for

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FOREWORD

This report describes the results of a workshop conducted to better define measurements of salmon and steelhead smolt survival and to outline research needs for Columbia and Snake river mainstem passage projects. The workshop was conducted by the University of Washington, Fisheries Research Institute (UW/FRI) and Pacific Northwest Laboratory (PNL) for the Bonneville Power Administration (BPA) at Friday Harbor, Washington, February l-3, 1989. Participants included individuals knowledgeable in survival estimation techniques and Columbia River research and management including representatives from federal and state fish and wildlife agencies, Indian tribes, the Northwest Power Planning Council (the Council), the Fish Passage Center (FPC),U.S. Army Corps of Engineers (USACE), public utility districts (PUDs), BPA, and universities.

The workshop report was prepared by James Anderson of UW/FRI, and Dennis Dauble and Duane Neitzel (PNL), with appendix conclusions by John Skalski of University of Washington/Center for Quantitative Science (UW/CQS) and James Anderson. Patrick Poe of BPA coordinated workshop logistics and directed preparation of the report.

The results of the workshop, presented here, represent the authors' interpretation of workshop participants' advice to BPA on how to proceed with the next steps in survival studies. It is BPA's intent to provide the workshop results as one source of information to assist the Reservoir Mortality and Water Budget Effectiveness Technical Work Group (RM/WBE-TWG) in their development of the 5-Year Work Plan for Mainstem Passage Research.

EXECUTIVE SUMMARY

A workshop was held at the University of Washington Laboratory at Friday Harbor February 1-3, 1989, to evaluate measures of juvenile salmon and steelhead survival and to recommend approaches for future studies in the Columbia River. Specific workshop goals included:

- review standards used to evaluate survival in previous studies and agree on standards for future studies
- evaluate existing methods for determining survival
- recommend types of survival studies that can be conducted with existing techniques
- identify new approaches and facilities for improving survival estimates
- reach consensus on future directions for survival studies.

During the first day of the workshop, individuals from participating agencies summarized the history and importance of survival studies from their agency's perspectives. These presentations were followed by a review of existing theory and a discussion of case studies. On the second day, participants divided into three working groups to address standards used to evaluate survival studies, discuss model evaluation and statistical theory, and develop recommendations for future survival studies. Each working group's recommendations were discussed on the third day. A new approach for estimating survival also was presented, and future directions for survival research were considered. Some representatives of the fisheries agencies and tribes (F&Ts) left the workshop before or during the final session because of previous plans and adverse weather. Final day participants included individuals from BPA, National Marine Fisheries Service (NMFS), UW/FRI, UW/CQS, USACE, and PNL.

Two major themes emerged during the first day's discussions. Speakers noted that uncertainty in the existing survival studies made it difficult to evaluate the effect of river flow on smolt survival. Some doubted that any single factor affecting juvenile survival could be isolated from any other factor, either natural or programmed, in the Columbia River Fish and Wildlife Program (the Program). Considering the high degree of uncertainty in study results, participants questioned the value of survival

speakers expressed the opinion that although "perfect research" is not achievable, it is useful to improve the quality of data on which decisions are made. In this context, a goal of the Program is to design research to reduce uncertainty in the relationship between the water budget and survival.

Overall, workshop recommendations suggest that current survival estimates have sufficient uncertainty and variability to limit their use in evaluating the effectiveness of the Water Budget Program and other programs (e.g., predator control) on smolt survival research. The standards group suggested that survival data cannot be used to evaluate or optimize the water budget. The model group expressed the opinion that survival studies were required as one element in a multivariate evaluation of the Water Budget Program. The future directions group stressed the concept of evaluating the water budget in terms of fish life cycles. The future directions group suggested that the relationship between water budget and fish travel time should be further investigated.

Most workshop participants agreed that valid survival estimates are needed to evaluate the effectiveness of the Program, including the effects of flow on survival. However, opinions differed as to what constitutes a valid survival estimate. To circumvent this problem, avenues of research were identified to clarify and reduce uncertainty in survival estimates and their application in program evaluation. In this context, the group determined that the role of the research is to present better information to decisionmakers, who must ultimately use this information to make decisions. Major recommendations include the following:

- Determine if survival experiments based on (Burnham et al. 1987) protocols RELEASE can be conducted. Uncertainty in proposed experiments should be analyzed according to procedures outlined by the model evaluation group.
- The theory for the epidemiological survival estimation method should be developed. Experimental protocol and uncertainty analysis of the method also need to be addressed.
- PIT tag facilities may need to be installed at additional Columbia and Snake river dams to improve survival investigations.
- The agreed to standard methods for fish handling, data recording, statistical analysis, and data management should be adopted in future survival experiments.
- Mechanistic multivariate life history models need to be developed.
- Research should focus on estimating survival of both juvenile and adult salmon.

LIST OF ABBREVIATIONS

AHCMR	Ad Hoc Committee on Mainstem Research
BPA	Bonneville Power Administration\
CBFWA	Columbia Basin Fish and Wildlife Authority
CRITFC	Columbia River Intertribal Fish Commission
c s u	Colorado State University
F&Ts	Fisheries Agencies and Tribes
FERC	Federal Energy Regulatory Commission
FGE	Fish Guiding Efficiency
FPC	Fish Passage Center
MEG	Monitoring and Evaluation Group (see p. 16)
NMFS	National Marine Fisheries Service
Council	Northwest Power Planning Council
ODFW	Oregon Department of Fish and Wildlife
PIT	Passive Integrated Transponder
PNL	Pacific Northwest Laboratory
PNUCC	Pacific Northwest Utilities Conference Committee
Program	Columbia River Basin Fish and Wildlife Program
PUD	Public Utility District
RM/WBE	Reservoir Mortality/Water Budget Effectiveness
TWG	Technical Working Group
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
UW/CQS	University of Washington/Center for Quantitative Science
UW/FRI	University of Washington/Fisheries Research Institute
WDF	Washington Department of Fisheries

INTRODUCTION

INTRODUCTION

A goal of the Columbia River Fish and Wildlife Program is to increase the production of salmon and steelhead in the Snake and Columbia rivers with maximum effectiveness and at a reasonable cost to electric utility ratepayers. One key component in attaining this goat is to increase the mainstem survival of migrating juvenile fish. Effective survival measures are required to assess progress toward achieving this goal. However, experience from Columbia River system studies has demonstrated that it is difficult to obtain meaningful and realistic measures of juvenile fish suwival.

To provide input for improving measurements of juvenile fish survival, BPA requested that UW/FRI and PNL assemble fisheries experts to discuss methods of estimating juvenile fish survival in the Columbia River. A workshop was held at the University of Washington Friday Harbor Laboratories, February I-3, 1989, to review past research and techniques for estimating survival and to recommend future directions of research to improve measurements of juvenile fish survival.

The Friday Harbor workshop was the third in a series addressing the measurement of juvenile fish survival in the Columbia River system. A 1-day reservoir mortality workshop, sponsored by the Columbia Basin Fish and Wildlife Authority (CBFWA), was held in Portland, Oregon, April 13, 1987 (Willis 1987). The workshop brought together experts to better define the role of reservoir mortality studies in passage and migration research and management. A second workshop, conducted in July 1988, provided in-depth coverage of techniques for estimating survival from release-recapture data as presented in Burnham et al. (1987). This workshop was conducted by the Colorado Cooperative Fish and Wildlife Research Unit at Colorado State University (CSU) in Fort Collins, Colorado.

The workshops culminate three decades of research and management of the problems of juvenile fish survival in the Columbia River system. Fish survival during downstream migration was first studied in the 1950s by the Washington Department of Fisheries (WDF) and the USACE, and again in the 1970s and 1980s by the mid-Columbia River utilities (i.e., Chelan, Douglas, and Grant County PUDs) to assess the effects of passage at hydroelectric dams on juvenile salmonids. These studies resulted in implementation of specific management strategies and facilities (i.e., fish bypass facilities and transportation) designed to improve juvenile survival and subsequent adult returns. More recently, the NMFS and the FPC conducted studies to

estimate the suwival of juvenile salmonids migrating through reaches of the Snake and Columbia rivers. An apparent relationship between flow and survival was found, at least for low flow years, when average yearly survival values were plotted against average yearly flows. Based on this information and indirect evidence that high flow should have a-positive impact on survival, the Council determined that increased spring flows are needed on the Columbia and Snake rivers to improve juvenile salmon migration. The Council then developed a "Water Budget" Program to allocate part of the river flow between April 15 and June 15 for fish during the spring migration period.

Because the water budget is based on yearly averaged information, refinement is warranted. Thus, the Council stipulated the need for additional information on the relationship between juvenile fish survival, travel time, and flows. Research is also needed to examine the relationship between flows and subsequent adult returns. The Council would use this information to determine whether the water budget is successful at increasing smolt suwival. If the research concludes that a quantitative evaluation of water budget effectiveness is not possible or feasible, the conclusions must be justified.

A Technical Work Group (TWG) on reservoir mortality and water budget effectiveness (RM/WBE-TWG) was established with the charge of developing a research plan to evaluate water budget effectiveness in increasing juvenile suwival and the importance of reservoir mortality. The Ad Hoc Committee on Mainstem Research (AHCMR) posed five specific questions that related directly to the issue of survival studies to provide guidance to the RM/WBE-TWG:

- Do we have the capability to obtain survival estimates for evaluating the effectiveness of the water budget?
- What assumptions exist for estimating survival and the problems encountered in meeting these assumptions?
- What are the chances of surmounting the problems in meeting study assumptions, and how long will it take?
- If it does not appear possible or feasible to estimate survival, are there priority questions that we can pursue, e.g., what are the threshold flows for fish movement? How soon could such questions be answered?

- Is predation a significant factor in mainstem survival? Is it likely that we can develop mechanisms to control predation within the next two decades?

The RM/WBE-TWG provided qualitative responses to these questions. The purpose of the Friday Harbor survival workshop was to re-evaluate the questions and provided a more quantitative basis for the answers. Specific goals of the workshop were to:

- review standards used to evaluate juvenile fish survival in previous studies and agree on standards for future studies
- evaluate methods for determining survival
- provide recommendations for the types of survival studies that can be conducted with existing techniques
- identify new approaches and facilities for improving survival estimates
- identify future directions of survival studies.

SCOPING SESSION

A committee of individuals knowledgeable in survival estimation techniques and Columbia River research participated in an initial planning/scoping session for the Smolt Survival Workshop on August 15, 1988. The purpose of the session was to define the objectives and tasks of a workshop focused on the feasibility of reservoir mortality studies in Columbia and Snake rivers mainstem passage research. Dale Johnson (BPA, Division of Fish Wildlife) facilitated the session, which was attended by 19 representatives from federal and state fish and wildlife agencies and tribes, the FPC, the Council, USACE, the Pacific Northwest Utilities Conference Committee (PNUCC), BPA, and UW/FRI.

The committee agreed the workshop should include a review of existing information and a description of both operable and inoperable hypotheses. Continuation to further stages of research planning was to be contingent on committee evaluation of the products from the first stage. The topic of the workshop was determined to be techniques for estimating juvenile fish survival. The results from the workshop would be used by the RM/WBE-TWG to help answer questions posed by the AHCMR and to assist in the development of the 5-Year Work Plan for Columbia and Snake rivers mainstem passage research.

The final agenda of the Friday Harbor Survival Workshop was developed from recommendations of the scoping session committee and further discussions with

members of the RM/WBE-TWG. The committee emphasized that individual presentations would not advocate specific positions and that the workshop would include open discussions.

Before the workshop, a list of potential participants was compiled from previous workshops on related topics. Additional participants were selected based on conversations with individuals on the initial list and members of the RM/WBE-TWG. A formal letter of invitation was sent by BPA to each invitee several weeks before the workshop. This letter included information on the workshop approach, goals, content, and schedule.

WORKSHOP STRUCTURE

The smolt survival workshop was organized in three parts. On the first day, presentations were given on the history and importance of survival studies from the perspective of the different agencies involved in the Fish and Wildlife Program. The purpose of these presentations was to provide a framework for discussion of agency priorities, data application, and research needs. The existing theories for measuring survival were discussed, and case studies using the techniques were reviewed. On the second day, the workshop divided in three groups to address specific goals (see Appendix F for composition of the working groups).

- A standards group focused on identifying what standards were used in past studies and what standards should be used for future studies. The discussion included methods, assumptions, theory, and experimental procedures that have been or should be common to survival tests throughout the Columbia River Basin.
- A model evaluation group discussed two mechanistic models that predict movement and survival of migrating fish. Directions in model development and the role of mechanistic models for evaluating statistical models were discussed.
- A future directions group discussed the future of survival studies and provided recommendations for development of new theory and facilities.

The results of the group sessions were reviewed by participants on the third day of the workshop and future research needs were discussed.

IMPORTANCE OF SURVIVAL STUDIES IN THE COLUMBIA RIVER FISH AND WILDLIFE PROGRAM: AGENCY PERSPECTIVES

IMPORTANCE OF SURVIVAL STUDIES IN THE COLUMBIA RIVER FISH AND WILDLIFE PROGRAM: AGENCY PERSPECTIVES

U.S. FISH AND WILDLIFE SERVICE. BY FRED OLNEY

The Council's Fish and Wildlife Program specifically called for exploring the relationship between flow and survival and subsequent adult return, with respect to implementation of the water budget. However, we have been unable to obtain estimates of survival through a reach of the river or reservoir with sufficient accuracy and precision to provide meaningful results. Even if we can overcome these problems, it may not be possible to devise and execute an experiment that isolates the effect of the water budget or any other factor or activity affecting juvenile fish survival from other factors affecting survival. The development of a flow/survival relationship is an oversimplification of a complex multivariate system. Many factors affect juvenile survival, and are expected to change in the future. Future changes will include implementing programs to control predation, installing and improving bypass facilities, and improving fish condition. Even with a long-time series of data, it is doubtful that the influence of flow could be sorted out from other factors affecting survival down to the incremental level useful to management (<20,000 cfs).

If the problems with precision and accuracy could be overcome, we could possibly use survival estimates through a reach as a measure of progress in improving fish survival under the Council's program. However, this measure would be in response to the combined effect of activities, rather than to manipulation of a specific activity.

To measure survival to Bonneville through a reach is just part of the story when evaluating the progress of the Fish and Wildlife Program. Juveniles have a long way to go from Bonneville to the ultimate measure of success (total adult production). Fish condition is important. We could have excellent survival to Bonneville, but if fish are in poor condition they won't do well during the transition to salt water. The time of arrival is another factor that has to be taken into consideration. There may be a critical window for optimum survival during early ocean rearing that would not be evaluated by measuring reach survival above Bonneville.

There are major problems to overcome in the accuracy and precision of survival estimates, and questions on what those estimates really mean. We should focus on groups of fish where we have a more complete picture of their life history so we can conduct a fairly complete cohort analysis (e.g., U.S./Canada indicator stocks). Use of those groups with an adequate number of marks and recoveries will allow us to remove some of the variability.

IMPORTANCE OF SURVIVAL STUDIES IN THE COLUMBIA RIVER FISH AND WILDLIFE PROGRAM: AGENCY PERSPECTIVES

BONNEVILLE POWER ADMINISTRATION, BY STEVE SMITH

The region has been trying for several years to get a better understanding of how to proceed with survival studies. I hope the results of this workshop will give us the guidance we need on how to proceed. I would like to briefly repeat some of the main points that I made at the Reservoir Mortality Workshop in Portland in April 1987:

- Mainstem passage is the key to effective rehabilitation of our upriver salmon and steelhead runs.
- Reservoir mortality is the primary cause of fish losses in the migration downriver, even overshadowing the effects of the dams themselves.
- We need to understand both the extent and cause of reservoir mortality. Knowledge of extent is important to justify the expense of determining the causes and solutions. Knowledge of extent is also important to annual and long-term planning of fish passage operations and facilities.
- I also encouraged the region to evaluate our fish passage issues based on system survival of individual stocks. We are seriously jeopardizing our ability to find effective long-term solutions to passage mortalities by judging potential improvements on a dam-by-dam or pool-by-pool basis. We must evaluate each of our individual efforts in terms of healthy smolts delivered to below Bonneville Dam (and ultimately returning adults).

Today, I would like to offer three main points for consideration. The first point is under the category of cost and politics. BPA's ratepayers are spending about $100 million annually on mainstem passage improvements. This includes water budget, fish spills, payment for existing fish facilities at Corps of Engineers dams, and the costs for research and the FPC's programs. BPA's management and our customers are speaking louder on what is being achieved for these costs and we can't tell them! I don't know where this will eventually lead, but our inability to substantiate benefits in improved smolt survival to these passage programs could and should jeopardize their existence.

Secondly, significant improvements in mainstem survival are the key to rehabilitation of upriver runs. It was the cumulative loss of fish by dams that caused the decline and it will be improvements, assessed cumulatively, that correct the problem. We have embarked on many initiatives to gain this improved survival. We are burning up our collective energies, time, and dollars, but for what? Are the options

we are pursuing working, and to what extent? As we pursue these courses of action with vigor, without a good (or any) understanding of their impacts on survival, we risk not being able to implement the solutions that will ultimately work. We are only going to be given so many dollars and so much time to show survival improvements. Each time we implement a new action without knowing its contribution to system survival we "bum some chips" and narrow our future options to achieve the survival we need. Additionally, ongoing system/sub-basin planning will guide our long-term investments in salmon and steelhead rehabilitation. We need passage survival data to allow these planners to make the right decisions on both future expenditures of dollars and on the future of some fish stocks.

My third point is that while we may not be able to conduct "perfect research" on mainstem survival and that we might not be able to get information without some risk in interpretation and use, can we at least get information today and in the near future that is of significantly better quality than that on which we are now basing our decisions? The rehabilitation of upriver runs depends on what I believe is our reliance on what is, at best, weak information on passage. We are spending large amounts of money. Thus, we need better passage survival data to increase our certainty that these actions will produce desired results and that results are obtained in an efficient manner.

IMPORTANCE OF SURVIVAL STUDIES IN THE COLUMBIA RIVER FISH AND WILDLIFE PROGRAM: AGENCY PERSPECTIVES

COLUMBIA RIVER INTERTRIBAL FISH COMMISSION, BY PHIL MUNDY

The Columbia River Intertribal Fish Commission (CRITFC), along with the Northwest Indian Fish Commission, Oregon Department of Fish and Wildlife (ODFW), Washington Department of Fisheries (WDF), and others, are fundamentally a harvest management agency. Our primary interest is salmon production and conservation. The treaty Indian fisheries is somewhat different from the non-Indian commercial, sport, and subsistence fisheries because they have geographic constraints imposed on them. Our production goals are different than others. We want production above Bonneville and production in all suitable drainages. The role of the CRITFC in the Fish and Wildlife Program is to see that the research money is well spent. We want maximum fish for the minimum cost. The success of the program is really measured by total fish production. We are very sensitive to the need to defend the program to ratepayers and don't want to be involved in a program that is not cost-effective. Adaptive management is mentioned in the program and is on paper within the technical working groups, but it is not really practiced. If you have no evaluation, you have no learning, and if you have no learning, you have no improvement. And this is not acceptable.

I say yes to evaluating system survival to Bonneville and to estimates of individual treatment effects. We should integrate the concept of survival over the life cycle of the fish. This would include some measure of marine survival in models because we can expect dramatic changes in impacts to certain stocks because of changes in offshore fisheries. International fishing agreements have resulted in changes in fishing intensity and timing that will affect adult returns. I favor mass marking of hatchery fish (excluding fin clips). We could use rare earth elements or manipulate fine-structure of otoliths through temperature control as a tool for tracking stocks. We are philosophically managing for both wild and hatchery fish, but realistically we are managing mostly hatchery fish. This is inconsistent with the use of current models that depend on the fact that wild and hatchery stocks are parallel or are behaving similarly.

In summary, survival must be measurable in some form if we are to have long-term accountability for the resource. We must be able to determine if changes (good or bad) are the result of good harvest management or because of some other factor.

IMPORTANCE OF SURVIVAL STUDIES IN THE COLUMBIA RIVER FISH AND WILDLIFE PROGRAM: AGENCY PERSPECTIVES

NORTHWEST POWER PLANNING COUNCIL, BY CHIP MCCONNAHA

The Council is interested in measures of smolt survival for three reasons: 1) water budget effectiveness, 2) system monitoring and evaluation, and 3) analysis of system and project measures. Each of these reasons will be discussed briefly.

Water Budget Effectiveness

The Water Budget Program was created in response to the Act's mandate to provide flows "at and between" projects to enhance survival. The Council took testimony from Fisheries Agencies and Tribes (F&Ts) and others regarding why flows were needed and the biological requirements. They concluded that flows were needed to decrease travel time to deliver fish to the estuary within some physiological window or time period. The Council's method of providing those flows was the water budget volumes.

The Council's interest in smolt survival estimates and reservoir survival addresses the Act's mandate to provide flows that improve survival. This is a separate issue from whether the water budget is an effective vehicle to provide those flows. Whether the water budget is an effective means of supplying flows should be addressed through hydrological investigation and through policy-level discussions with power interests and project operators. Defining the biological requirements for flow can be addressed by two questions: 1) How do smolts respond to flow? (i.e., How much flow does it take to get fish to move at certain rates?), and 2) How quickly do fish have to be delivered from headwater rearing areas to the estuary?

The first question can be answered relatively easily through investigation of flow/travel time relationships. Passive Integrated Transponder (PIT) tags offer the ability to obtain much information in a relatively short time. It is important that physiological condition also be factored into flow/travel time models. The second question can be addressed through physiological investigation of the length of time and factors (temperature, stock, etc.) that may affect the duration of the time period. This approach does not necessarily require direct estimates of smolt survival. Instead, physiological requirements become a surrogate for direct estimates. Information regarding physiological needs and flow/travel time relationships can be used to refine our model of reservoir passage and to clarify flow requirements.

IMPORTANCE OF SURVIVAL STUDIES IN THE COLUMBIA RIVER FISH AND WILDLIFE PROGRAM: AGENCY PERSPECTIVES

System Monitoring and Evaluation

The Monitoring and Evaluation Group (MEG) has examined the problem of monitoring and evaluating the Fish and Wildlife Program and has concluded that there is no single best measure of progress. While various approaches are available, each measures different aspects of the program. Second, it was not possible to directly separate program effects from nonprogram effects such as changes in harvest or natural survival rates. Additionally, effective monitoring of the program must proceed from the foundation of a life-cycle model. The model would be used to factor out nonprogram effects and to explore the effects of various program actions. The model would be used to generate testable hypotheses about various aspects of the life cycle. It could be refined over time to better track the progress and effectiveness of the program.

An important component of this approach will be an effective model of mainstem passage to track progress. Estimates of smolt survival through the system will be needed to calibrate the model and to provide direct input to the monitoring program. Without additional analytical work, it will not be possible to segregate the effects of reservoirs, flows, spills, physiological condition, etc., from this estimate. Instead, the measure will index the effect of the program and will form an important component of the MEG approach to monitoring.

System Analysis and Project Measures

The Council and others need to compare and analyze proposals for meeting the obligations of the Act. An important aspect of planning is the analysis of potential effectiveness and refinement of proposals. This can be done through modeling or other analytical techniques. Examples include system planning where extensive analysis of alternative production schemes is being conducted by the agencies, tribes, and the MEG. The accuracy of these analyses is dependent on our knowledge of how system components operate. An important parameter in all analyses is the survival of fish through the mainstem Columbia and Snake rivers. I suggest that a useful exercise for this workshop, and it will be an aim of the upcoming predator-prey workshop, is to review existing models of reservoir survival and suggest improvement, if any are required.

IMPORTANCE OF SURVIVAL STUDIES IN THE COLUMBIA RIVER FISH AND WILDLIFE PROGRAM: AGENCY PERSPECTIVES

U.S. ARMY CORPS OF ENGINEERS, BY JAMES ATHEARN

The Corps of Engineers decisionmaking process is mandated by Congress. Specific steps must be taken for feasibility studies through authorization of specific projects. The Corps must use economic analyses as one basis for decisions and recommendations to obtain authority for specific projects. A good data base is needed to do economic analyses that will stand up to congressional scrutiny during a budget testimony. We must have factual information to convince Congress to approve programs that may cost hundreds of millions of dollars. There is a strong hesitancy to support weak arguments or opinions that are not fully supported by data.

Six areas of emphasis are identified under the Council's Fish and Wildlife Program. These include four for BPA funding responsibility, e.g., reservoir mortality and water budget effectiveness and two identified for the Corps of Engineers. The Corps' areas include transportation and bypass facilities. Bypass studies have looked at juvenile fish survival associated with project passage through various routes at Bonneville Dam. The Corps' emphasis is site specific at the dam. However, we are aware that you can't look at individual dams without looking at the entire system or at cumulative effects.

Our interest is in what is the best passage route past the project. This is not limited to just looking at facility survival, but includes evaluating effects down through the tailrace as far as the area of influence is distinguishable. It is important that we be able to demonstrate that the spill bypass program is cost-effective when it results in a revenue loss of up to $10 million per year.

We want to be able to make informed decisions based on the best scientific data to optimize passage conditions and pick the best passage alternatives. It is in everyone's best interest to develop methods that accurately determine juvenile fish survival and to identify study approaches that can be conducted using existing facilities and technologies. Having the best scientific information is the key to making decisions and following through on our recommendations.

IMPORTANCE OF SURVIVAL STUDIES IN THE COLUMBIA RIVER FISH AND WILDLIFE PROGRAM: AGENCY PERSPECTIVES

CHELAN COUNTY PUBLIC UTILITY DISTRICT, BY DICK NASON

Although I am interested in what's happening on a system-wide basis, my primary concern is with Rocky Reach and Rock Island Dam. Most of you are familiar with our bulb turbine mortality study done in 1979, a study that went to hearing in 1985. This eventually resulted in our support of the AFS Monograph (Burnham et al. 1987) as an attempt to develop better standards for survival studies. In 1985, we reached a settlement agreement on Rock Island Dam that is now part of our operating license. This agreement includes a phase II hatchery production to be used to supplement the wild run. A project survival study with juveniles is required by 1995 (or when bypass systems are in place at Rock Island) to determine a compensation level for hatchery production. We want a survival study where standards can be agreed to in advance, so that we can use it by 1995. The standards should include both biological and statistical considerations. Modeling will not work in a case like this. The bottom line is that we need to know what percent mortality is associated with Rock Island Dam.

REVIEW OF SURVIVAL ESTIMATION TECHNIQUES

REVIEW OF SURVIVAL ESTIMATION TECHNIQUES

PROGRAM RELEASE, BY DAVID R. ANDERSON AND KENNETH BURNHAM

The purpose of this presentation is to provide an overview for those who did not attend the Fort Collins Workshop.(a) We got involved in studies at Rock Island Dam in 1979, and one realization from those experiments was the need to develop general statistical theory for capture-recapture studies with animals. Although our mindset was locked in with hydroelectric dam studies on the Columbia River, the subject has much broader application. The theory is not restricted to just obtaining estimates of survival for fish passage studies. Other people are conducting interesting experiments with marked animals, including lizards, birds, etc.

Our work for Chelan County led to development of protocols for individual tag studies and subsequent publication of the AFS Monograph (Burnham et al. 1987). We were given the freedom to examine the background of theory over the past several decades relating to sampling of marked animals. A series of protocols was developed in our book that can be used for a range of studies involving animals with unique tags to single-recapture animals that are removed from the population. This provides a lot of flexibility in sampling design.

Previous studies in the Columbia River used estimators of survival based on recapture ratios of treatment and control groups. The assumption was that the capture probability of control and treatment groups was the same. However, we don't know if that was true. We looked at a series of models that gave different estimators. There are a battery of tests that can be done and that will tell you for a given experiment what seems to be the best model that describes the variation in data. The monograph provides ways to estimate sampling variance and other guidelines for designing experiments (i.e., sample size, how many dams needed downstream, capture rates). Another point that needs to be made is the critical need for repetition. For example, it may be advantageous to release more groups with smaller numbers versus a few groups with a large number of marks.

Program RELEASE is a general program described in the monograph that computes estimates of treatment effect, survival, and capture probabilities from release-recapture data for one or more groups under one of four sampling protocols. A battery of experiments that relate to appropriate models for release studies are

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(a) Workshop design and analysis methods for fish survival experiments based on release-recapture, July 6-8, 1988, Colorado State University, Fort Collins, Colorado.

described. The computer program RELEASE can be used for design and analysis on a PC or Sun workstation. It is a user-friendly program with several options to conduct analysis without working through all the formulas. RELEASE has a Monte Carlo simulation capacity that you can use to challenge assumptions and look at bias. This will tell you if the survival estimate is changed and the degree of change. You can then determine if this change is meaningful.

There now exists a moderately complete theory for analysis of studies with marked animals. This includes multiple treatment groups, ordered treatment groups, PIT tags or removal-type experiments, and there is a lot of theory for variance estimators. There is the ability to do modelling within estimator procedures to test assumptions. You can add more factors as covariates to the model, i.e., flow rates, fish size, fish condition, etc. Thus, we are not limited by our ability to analyze data or design studies. However, the practical problems may limit the ability to meet the model assumptions. For example, natural, individual heterogeneity must be recognized. Not all fish have the same capture or survival probability.

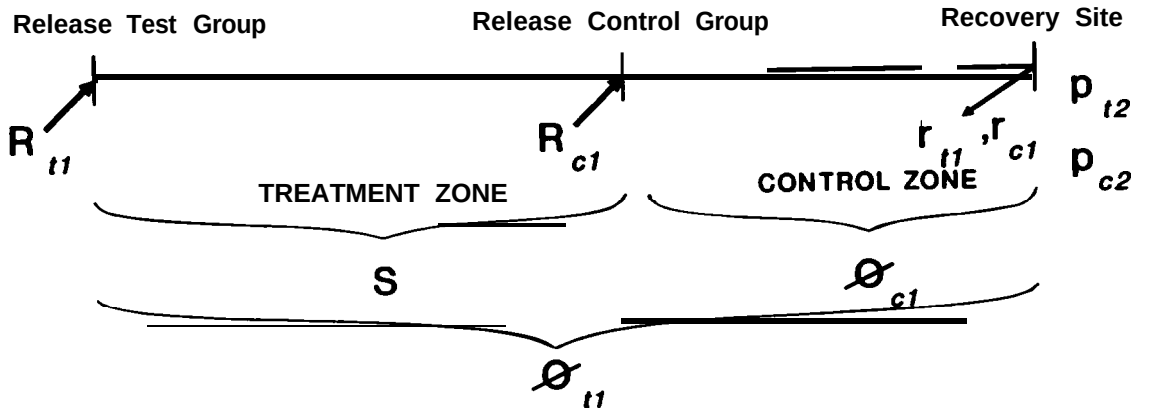
FISH PASSAGE CENTER EXPERIENCES IN CONDUCTING SURVIVAL STUDIES USING THE INDIRECT METHOD, BY TOM BERGGREN

While conducting survival studies in the mid-Columbia and Snake rivers between 1984 and 1987, the FPC realized the difficulty in meeting assumptions required to estimate survival using the indirect method when the objective is measuring survival through a reservoir or over a series of reservoirs. This presentation will address the problems we experienced in meeting design assumptions and will shed light on problems that need to be overcome before future studies on reach or reservoir survival are attempted.

With the indirect method of estimating survival, a test group is released at the head of the reach of interest, a control group is released at the end of this reach, and survival is estimated between these two points. For our survival studies, estimates were obtained for Winthrop Hatchery spring chinook and Wells Hatchery steelhead migrating to Priest Rapids Dam and for Lyons Ferry Hatchery steelhead migrating to Ice Harbor Dam. In the mid-Columbia, five dams and four reservoirs were in the treatment zone; in the lower Snake River, two dams and two reservoirs were involved.

Using the same notation as Bumham et al. (1987), shown in Figure 1, S is the survival parameter for the treatment zone, the reach of interest. The parameter p is the collection efficiency at McNary Dam for each group, and the parameter ø is the survival of each group from release to recovery. The ratio of the recovery proportion of test to control group gives an estimate of this survival. This estimator is equivalent to all the estimators in the monograph when only one recovery site is available. R is the number of fish released, and r is our passage index number. The passage index number is the value obtained after expanding the sample number by the inverse of the sample rate and the proportion of flow passing through the powerhouse. The first expansion is needed since freeze-branded fish were used in the studies, and only a subsample of the collected fish at McNary were hand-processed. The second expansion is used to adjust the collection on all days to the potential number of fish collected if no spill had taken place. This adjustment assumes fish pass the project in direct proportion to the flow through each route.

In discussing design assumptions, we need to look at the model parameters for group survival and p for group collection efficiency. The product ø x p is estimable, but the individual parameters are not separately estimable. This also is true for the first capture history protocol in the monograph when more recovery sites are available. For the ratio to estimate what is desired, we need to make two key assumptions about



$$\hat{S} = \frac{\phi_{t1}\, p_{t2}}{\phi_{c1}\, p_{c2}} = \frac{r_{t1}/R_{t1}}{r_{CI}/R_{c1}}$$

assumption 1: $p_{t2} = p_{c2}$

assumption 2: $\phi_{t1} = S\phi_{c1}$

FIGURE 1. Description of Parameters Used in Calculating Smolt Survival Based on the Indirect Method (Bumham et al. 1987)

these parameters. First, and most important, is that the collection efficiency of the test and control groups is equal. If this assumption is met, the ratio estimator will estimate the change in survival of the test group relative to the control group. If we also assume that test and control groups have the same survival in the control zone (the area through which they both migrate) then the ratio estimator will give an absolute estimate of survival in the reach of interest.

To satisfy these two assumptions, researchers strive to keep the test and control fish biologically identical before release. They do not want handling, marking, and holding effects to impact survival after release. Second, they want the test and control fish to move together downstream to the recovery site. This will make both groups susceptible to the same levels of predation and make the temporal recovery distributions of both groups coincide. In practice, it is difficult to perform these two actions successfully.

REVIEW OF SURVIVAL ESTIMATION TECHNIQUES

In 1984 and 1985, we tried to lag the release of the Wells Hatchery steelhead control groups later than the test groups, so that both groups would migrate together in the control zone and be mixed when they were recovered at McNary Dam. For each of the three replicate releases in the first year, test fish were collected from a pond, marked, and released first; control fish were collected, marked, and released about 1 week later. Unfortunately, fish had to be taken from three different ponds, and by the time the last pond was used, differences were noted between the sizes of test and control fish for the last replicate. Design problems were evident as this later control group had a lower recovery proportion than the earlier control group releases. In the second year, the test and control fish for each replicate release were collected from the same pond and marked at the same time. In the hope of achieving mixing between test and control groups, the control fish were held in raceways about 5 to 7 days longer before release. The control groups were subjected to additional stress, which had a noticeable impact on the recovery rate of the last replicate group. In the following 2 years, the test and control groups for each replicate at Wells Hatchery was collected and marked at the same time. After an identical holding period, both groups were released on the same day. Thus, we shifted from trying to get mixing between the test and control groups to trying more to maintain equality of pre-release conditions. Because of what we learned with the Wells Hatchery groups, lagging the control group releases was not attempted with the Winthrop and Lyons Ferry Hatchery groups.

There was a difference in pre-release handling of the test and control groups because of the need to transport the control fish farther than the test fish to the release sites. The alternative of simply driving the test groups around for an equal amount of time was not practical. We were concerned that the control group's survival after release could be impacted from stress from the longer hauling time. USFWS monitoring of stress indicators in 1987 showed that, in most cases, where both test and control fish were transported, the control groups were no more stressed at time of release than the test fish. Winthrop chinook test groups were not transported at all, so the control groups had a higher level of stress at time of release. However, our main concern was with the steelhead groups, since survival estimates with these groups were exceedingly high. The estimates obtained would imply over 95% per project survival for Wells Hatchery steelhead and over 100% per project survival for Lyons Ferry Hatchery steelhead. The Winthrop spring chinook estimates averaged closer to 85% per project survival, also potentially high. The unreasonable estimates for steelhead caused us to look closer at design assumptions for clues.

There appeared to be behavioral differences between test and control groups by the time both were travelling through the control zone. The control group fish migrated slower after release through the control zone than the test group fish when they arrived at that zone. This was evident by comparing the migration speeds from release to McNary Dam. If slower travel time in the control zone translates into greater exposure to mortality because of predation, then the assumption of equality of survival between the test and control groups in the control zone may be violated. This slower migration speed of control groups might impact the survival estimates. More important is that the collection efficiency of the test and control groups may have differed because of behavioral aspects of the fish.

During the final year that the FPC conducted survival studies, the USFWS looked at the physiology of the test and control groups. The aim was to see if changes in the physiology or behavior of the fish were influencing our survival estimates. At Lyons Ferry Hatchery, the test and control groups had similars levels of ATPase, indicating similar development of smoltification. At McNary Dam, the control group's ATPase level was significantly lower than that of the test group. In addition, the ATPase level increased over time within a group, which could lead to violations of an assumption listed in the Burnham et al. (1987) monograph, that, "All fish of an identifiable class have the same survival and capture probabilities." In our situation, we had different degrees of smoltification development between test and control groups and also within the same group. The USFWS researchers found changes in ATPase development were related to length of time of in-river migration. The Lyons Ferry test fish migrated 91 miles to McNary Dam while the control fish migrated only 41 miles. In most years, the median number of days to travel from release to McNary Dam was about double for the test group (1 1-20 days versus 6-l 2 days). With longer time in river, we see greater smolt development.

These results would be inconsequential if there were no apparent behavioral tie between smoltification development and collection efficiency. However, based on Fish Guidance Efficiency (FGE) work conducted by NMFS at Lower Granite and Little Goose dams, there is evidence that implies fish further along in smolt development migrate higher in the water column and are more susceptible to interception by the traveling screens. If this behavior pattern is generally true, it has important consequences when designing survival studies using the indirect method. Differences in collection efficiency, attributable to differences in degree of smoltification, could bias survival estimates. By violating the assumption of collection efficiency, we are not

estimating survival, but rather a change in survival compounded by a change in collection efficiency, as in the case of the Lyons Ferry steelhead, which rendered a ratio value near 1.0.

Because a period of in-river migration is needed to speed up smoltification development, the practice of lagging the control group releases to get mixing in the control zone and at the recovery site is not adequate to achieve equal collection efficiency between test and control groups. In the Lower Granite pool survival study, the original intent was to lag the controls. However, fish health problems caused the lagging approach to be dropped. In hindsight, lagging the controls would probably not have advanced smoltification development enough so that test and control groups were in the same physiological stage in the control zone and at the recovery site. Mixing will only reduce the impacts that flow and project operations have on collection efficiency, since temporal changes in collection efficiency caused by changes in flow and project operations would apply equally to the test and control groups.

We have seen that the described methods were not successful in getting a test and control group of fish from a hatchery to the same level of smoltification development at the time they are migrating together through the control zone and when passing the recovery site. Lagging the hatchery control releases, with associated problems in handling the fish, was not the answer, since it would be difficult to elevate the ATPase level high enough without some in-river migration time. One possible solution is to use in-river fish. For example, we could release in-river fish as a test group at the head of a reservoir and mark and make a series of control group releases in the turbines or tailrace over the time this group passes the dam (marking the beginning of the control zone). With this scheme, one would attempt to move the test and control groups together through the control zone and by the recovery site or sites. The goal of mixing between test and control groups of comparable stock composition and smoltification development might be met. Or would it?

This optimistic view would work only if the collection of fish at each site for inclusion in the test and control groups was truly representative of the population of fish passing each marking site. This is the major flaw of this approach and a problem when collecting fish from places like the Snake River trap at Lewiston and Lower Granite, Rock Island, and Priest Rapids dams. Each site has its own level of bias in how representative its samples are of the population passing. Alternatively, one could use common gear, such as a purse seine, to collect fish at the head of the reservoir for test groups and in the forebay for control groups. But would the use of common

sampling gear, with its own level of sampling bias, provide representative enough samples for marking test and control groups? If you chose to use in-river fish, then the collection methods must be evaluated to determine which will provide the most representative segment of the population for marking test and control groups.

In conclusion, I want to stress that you must consider the physiological status of the fish to be used and how it can influence design assumptions. This is particularly true when the goal of the study is survival over a distance, whether an individual reservoir or a reach encompassing several reservoirs and hydroprojects. The following points must also be kept in mind:

- The treatment in these survival studies is distance.
- Smoltification development increases with days of migration, which is a function of distance and river temperature.
- Smoltification development can influence collection efficiency as more smolted fish may have a higher probability of capture.
- Mixing of test and control groups alone is not sufficient to guarantee equality of capture probabilities.
- Survival estimates will tend to be biased high if collection efficiency of control groups is less than that of test groups.
- Although physiological status is of primary concern, it must be remembered that there are other factors involved.

REVIEW OF SURVIVAL ESTIMATION TECHNIQUES

A REVIEW OF THE INDIRECT AND DIRECT METHODS OF COLLECTION EFFICIENCY STUDIES USED FOR ESTIMATING SMOLT SURVIVAL. BY AL GIORGI

Two methods employed for estimating smolt survival include the direct method and the indirect method. For the direct method, estimates of population size are obtained at one site, and the population is tracked to a downstream location. Any decrease in population size between the upstream and downstream and index sites is then used to estimate survival. You have to account for both infusion and extraction of fish in the area under question. In this case, the survival estimates are sensitive to the quality of the population estimate. This method may be more useful for looking at survival over a reach rather than through turbines.

The indirect method is based on the ratio of the recovery proportions of treatment to control groups. A number of estimation models are available, depending on the recapture capabilities of the system. This method may be used to generate both project-specific and reach estimates of survival. However, assumptions inherent to the method require particular attention. Several recommendations for using the indirect method were derived from the Fort Collins workshop on smolt survival. These include: 1) using groups of fish where complete capture history is known; 2) using a minimum of three dams for deriving estimates (i.e., release, recapture-release and recapture sites); 3) using a unique tag (e.g., PIT tag) is preferable; 4) replication is needed to generate an estimate of variance; and 5) survival is a robust estimate.

Collection efficiency (CE) is an important aspect in estimating population size for the direct method. CE is an estimate of the proportion of the migrant population passing a dam, which is entrained in the collection facility or captured by some other gear. It is not synonymous with either spill efficiency or fish guiding efficiency (FGE). However, it could be a measure of FGE when 100% of the flow is discharged through the powerhouse. Collection efficiency can be expected to differ among species.

For a population (N) that approaches a dam, there is a probability that some proportions (Ps) will go through the spillway and that the rest (Pp) will go through the powerhouse (Figure 2). The powerhouse fish can either pass through the turbines (Pt) or the bypass (Pb). Only the bypass fish are available for counting and identification. The proportion of fish entering the bypass system equals the FGE and collection efficiency or CE = Pp x Pb.

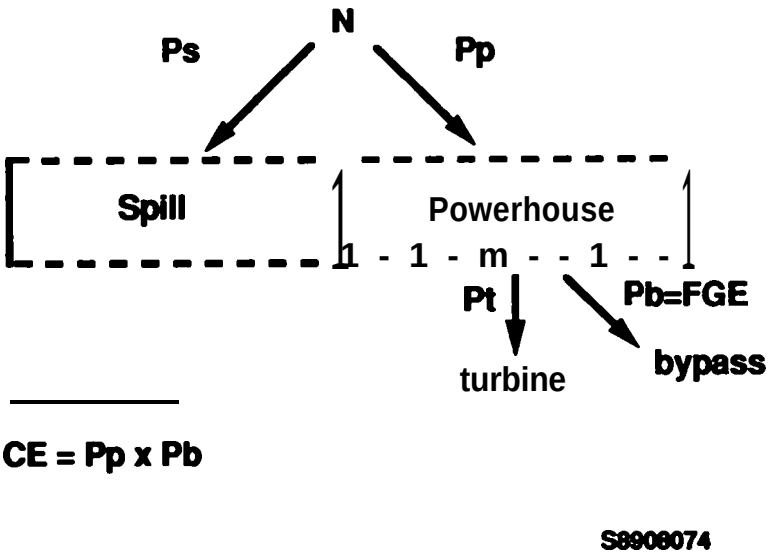


FIGURE 2. Method for Determining Collection and Fish Guiding Efficiency for Migrant Populations Passing a Dam

One way to estimate collection efficiency is by calibrating the dam. That is, you can determine how efficient your sampling device (dam) is by releasing marked groups of fish above the dam and by collecting them in the bypass at the dam. Alternatively, Pp and Pb can be estimated independently. This may be possible using hydroacoustics to estimate the number of targets entering the spillgates, powerhouse, or bypass system, thus providing data on the probability of fish encountering the bypass system. Other methods include the use of fyke nets to estimate Pb and radio-tagged fish to estimate Pp. The collection efficiency estimates can then be used to estimate population sizes as N = number collected/CE. Estimates of N at any two or more locations can be used to estimate the loss or mortality, between the sites (direct method).

Previous estimates of CE have been based on forebay releases that were recaptured in gatewells or other collection systems. Post-release mortality was never directly estimated. Species-specific calibration curves were then plotted to obtain a relationship between collection efficiency and river flow and/or powerhouse discharge. However, the quality of the curves is variable. Current research is attempting to identify the sources of bias and imprecision associated with estimates of CE.

CASE STUDIES: JUVENILE SALMON SURVIVAL

1987 LOWER GRANITE SURVIVAL STUDY, BY AL GIORGI

The objective of the Lower Granite study was to estimate survival of yearling spring chinook salmon as they traversed Lower Granite Reservoir and passed through a turbine at Lower Granite Dam. In February 1987, hatchery fish were PIT tagged at Rapid River Hatchery and transported to release sites. Three groups of fish (11,581 total) were released at each of the following locations: 1) 16 miles upstream from Asotin, Washington, into the Snake River; 2) into a turbine (Unit 3) at Lower Granite Dam; and 3) into the Lower Granite Dam tailrace (Figure 3). PIT tag monitors positioned in the bypass systems at Lower Granite and Little Goose dams provided

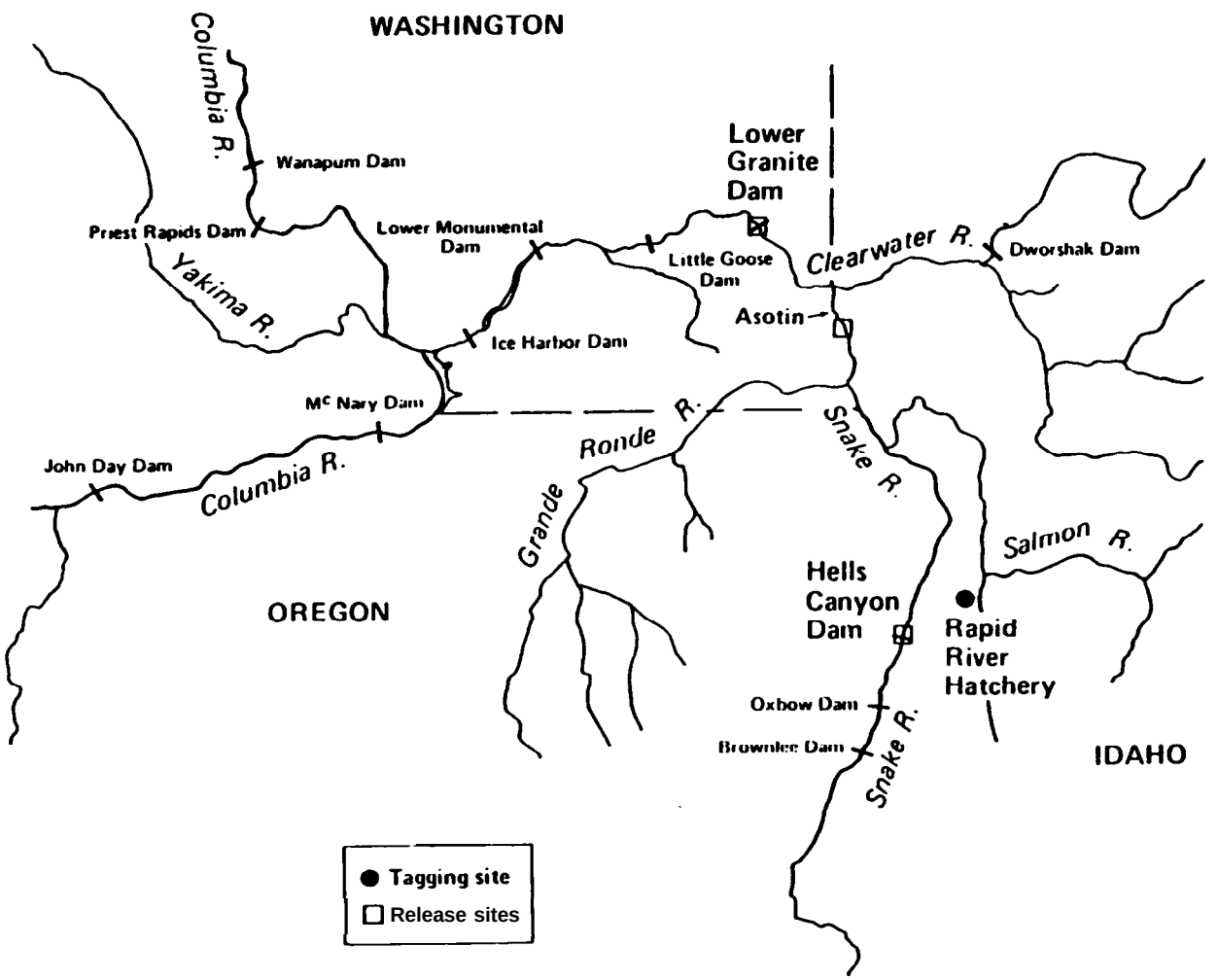


FIGURE 3. Study Area for the 1987 Yearling Chinook Salmon Survival Test (Giorgi and Steuhrenberg 1988)

recapture data for survival estimates. A 10-day delay between test and control groups was planned to improve the probability that mixing would occur at the Little Goose Dam recapture site. However, because of disease-related mortality and operational constraints at the hatchery, pool and dam groups were released only 1 day apart.

A total of 1,958 and 1,090 tagged fish were recovered at Lower Granite and Little Goose dams, respectively. Since nearly all yearling chinook salmon collected at Lower Granite and Little Goose dams were transported in 1987, no PIT-tagged fish were recaptured at more than one recovery site. Turbine survival at Lower Granite Dam was estimated to be 83%, and a qualified survival estimate for spring chinook salmon from Asotin to Lower Granite Dam was estimated at 72%. However, there were some uncertainties associated with satisfying certain key statistical assumptions.

The turbine and tailrace groups were generally mixed at Little Goose Dam, based on frequency distribution of arrival date. However, only the first Asotin release appeared to be mixed with turbine or tailrace release at Little Goose Dam. The lack of equal mixing is a concern when the sampling efficiency of the collection device changes through time. There was also a 2-week difference in the amount of time required for treatment and control groups to travel through the control zone from the control release site to the recapture site (Little Goose pool). One explanation for this difference was that spring chinook released from the Rapid River Hatchery were not ready to migrate. This is a plausible explanation based on a physiological index (i.e., low gill Na+-K+ ATPase activity). Because the time frame spent in the control zone differed, there was a possibility that the treatment and control groups incurred different levels of mortality due to biological and environmental factors (e.g., predation or water temperature).

The use of in-river migrants, rather than hatchery fish, could eliminate some of the problems encountered in this study. River-run fish could be collected upstream from the dam, tagged, and returned to the pool. Upon arrival at Lower Granite Dam, these fish would be removed from the collection system, tagged, and released in the area of interest. This design would provide the best mixing at Little Goose Dam and result in similar exposure periods in the control zone. However, the possible dissimilarity of the two groups becomes a concern and must be addressed. Design of future survival studies should also include the use of alternative estimation models that require PIT-type tags and utilize recapture data from all available downstream sites.

MID-COLUMBIA SURVIVAL STUDIES. BY STEVE HAYS

Investigations of juvenile salmon mortality were conducted in the mid-Columbia River from 1980 to 1983 as part of studies mandated by a Federal Energy Regulatory Commission (FERC) settlement agreement dated March 4, 1980 (Chapman and McKenzie 1981, McKenzie et al., 1984a, 1984b). The Mid-Columbia Studies Committee, a group of six biologists representing Chelan, Douglas, and Grant county public utility districts, and the Washington Department of Fisheries, Oregon Department of Fish and Wildlife, and National Marine Fisheries Service (NMFS) directed these studies. They appointed a statistical subcommittee to establish the basic statistical requirements of a system mortality study.

In 1980, estimates of survival of spring chinook salmon smolts were obtained in the mid-Columbia River from the head of Wells pool to the tailrace of Priest Rapids Dam, and from there to the head of McNary pool (Figure 4). For this study, about 30,000 smolts were freeze-branded and released on each of three dates at three locations (near Pateros, at the tailrace of Priest Rapids Dam, and at Richland). Fish were recovered at McNary Dam in fish sampling facilities operated by the NMFS. Recovery data were complicated by an unstable turbine/spill operating regime at McNary during late May. Pateros releases moved through McNary Dam over about a l-month period, while Priest Rapids and Richland releases moved past McNary Dam in an interval of about 2 weeks. Survival rates were estimated using three methods: 1) using the collection efficiencies from the NMFS release and recapture data; 2) assuming that recovery efficiency was relatively constant during the recovery period (similar arrival times for groups within a replicate); and 3) assigning relative collection efficiencies to levels of spill and turbine flow. Survival estimates for Pateros to Priest Rapids ranged from 23 to 40%. The more limited data for Priest Rapids to Richland suggested a survival range of 83 to 95%. Collectively, these data implied a per-dam mortality rate of 17 to 25%. Several factors influenced the precision and accuracy of the estimates in 1980, including the eruption of Mount St. Helens, variable spill:turbine flow patterns, differences in arrival times of treatment and control groups, interpretation of brands, and sampling efficiency estimates.

Studies were resumed in 1982 to estimate cumulative mortality of juvenile salmon in the mid-Columbia and to assess incremental mortalities for juvenile chinook salmon migrating from the head of Wells Reservoir to a point just downstream of Priest Rapids Dam (Figure 3). Approximately 425,000 spring chinook smolts were freeze-

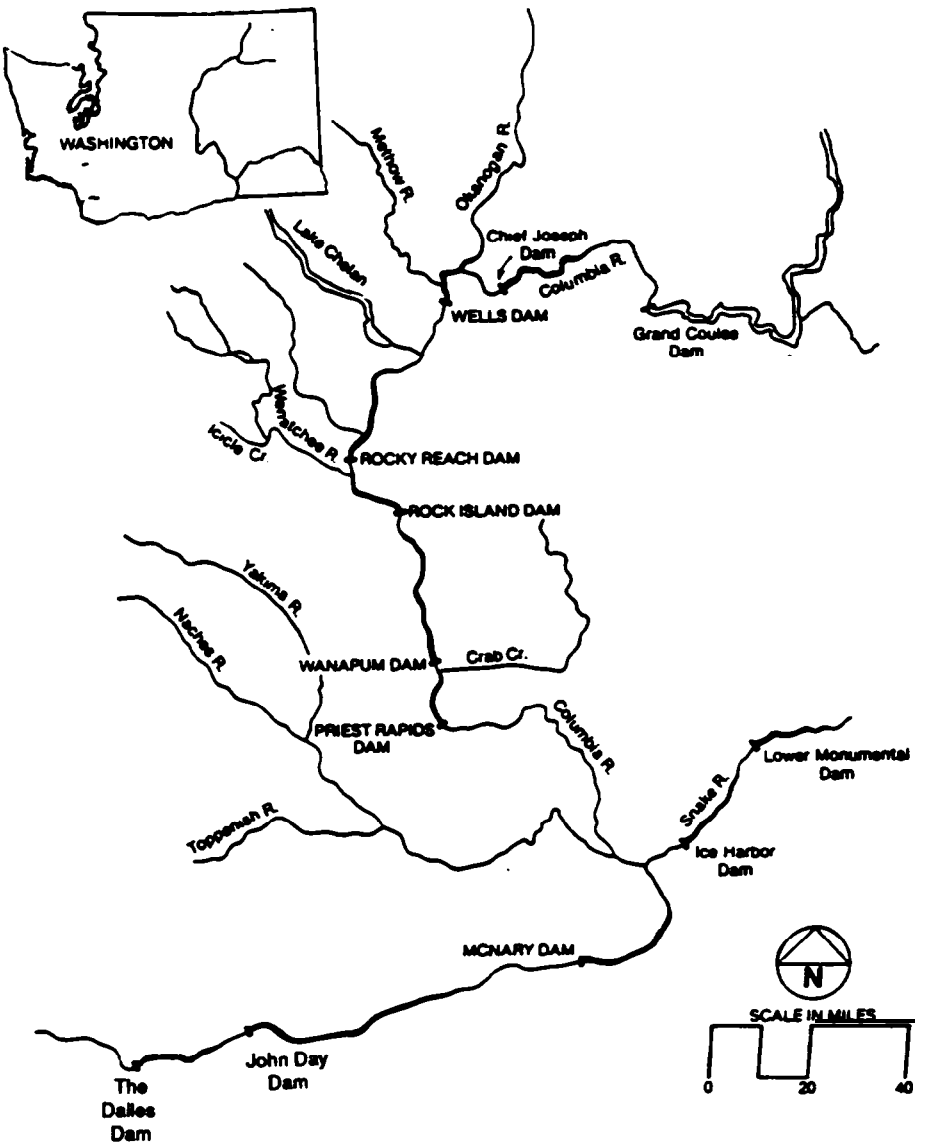


FIGURE 4. The Mid-Columbia Study Area (McKenzie et al. 1984a)

branded at the Leavenworth Hatchery and released at three locations in the mid-Columbia River from late April to late May. One test group migrated past five mainstem hydroelectric projects, the second group past only Wanapum and Priest Rapids dams, and the third group was released about 1 km below Priest Rapids Dam. Collection efficiency groups were also released in McNary pool to evaluate the percentage of the total run collected at McNary Dam. The number of replicates, timing of release, and number of fish released were varied to compensate for migration distance, migration rate, and differences in survival among groups. The survival rate (based on the direct

estimation technique) from Pateros to the Priest Rapids Dam tailrace was estimated to be 44%. The Pateros to Rock Island and Rock Island to Priest Rapids survival estimates were 65% and 64%, respectively. A per project survival rate of 87% for Wells, Rocky Reach, and Rock Island, and 83% for Wanapum and Priest Rapids dams was estimated, assuming equal project survival. The high spill volumes may have reduced turbine-related moralities in 1982. Thus, reservoir-related mortalities primarily contributed to the estimated mortality rates.

The system's mortality studies were repeated in 1983 to obtain information on year-to-year variability in survival rates. The principal objective was to estimate incremental mortalities for juvenile chinook salmon migrating from the head of Wells Reservoir to a point downstream from Priest Rapids Dam. The procedures were similar to those used in 1982. Both direct and indirect techniques were considered for estimates of relative survival rates. However, the amount of variability in collection efficiency accounted for by turbine and spill flow were low, suggesting that these regression estimators should not be used as a basis for estimating collection efficiency. Because of this condition, and because the migration timing of replicate treatment groups was similar, the indirect estimation technique was used to obtain relative survival rates in 1983. Single project survival rates were estimated at 84% for Wells, Rocky Reach, and Rock Island projects and 87% for Wanapum and Priest Rapids projects. Estimates of survival for the entire reach from Pateros to Priest Rapids were 45% or similar to those obtained in 1982.

Some of the between-year variability may be explained by differences in spill scenarios, including daily patterns of spill. However, it is evident that the perfect study is not there. It is up to us to deal with imperfections in the study design. Knowledge of how to handle differences in timing of recovery for the control and treatment groups is needed. It is also important to understand that determining smolt survival for management purposes is different than determining survival for compensation purposes.

JUVENILE SALMON SURVIVAL STUDY AT BONNEVILLE DAM, BY EARL DAWLEY

Construction of the second powerhouse at Bonneville Dam [Columbia River kilometer (Rkm) 233] included newly developed collection and bypass facilities for juvenile salmon and steelhead. When the system began operation in 1983, substantially fewer fish were intercepted for bypass than had been anticipated. Several years of research and subsequent system modifications have greatly improved collection efficiency for spring migrants; however, collection efficiency for subyearling summer migrants has not substantially improved. In light of the limited data on survival of juvenile salmon passing though the new, more efficient turbines of the second powerhouse, the second powerhouse bypass system, or spillways modified with flow deflectors, this is potentially a very serious problem. It is generally agreed that further improvement of diversion and fingerling bypass systems will be extremely costly. A program to assess comparative survival of juvenile salmonids passing through turbines, spillways, or bypasses was needed at Bonneville Dam to properly manage the project for maximum smolt survival. Accordingly, the research project summarized here was designed to evaluate relative survival of juvenile fall chinook salmon (upriver bright stock) using selected modes of passage at Bonneville Dam.

The study plan calls for the marking and release of about 2 million fish per year for a 3-year period. Juvenile fish are recovered by beach and purse seines at the head of the Columbia River estuary (Jones Beach, Rkm 75). Previous efforts by NMFS at this site between 1966 and 1983 demonstrated the ability of such sampling to provide a statistically valid assessment of downstream relative survival. Two crews operate 7 days per week with the major effort directed to the gear (beach or purse seine) recovering the greatest numbers of fish. This short-term assessment of relative survival is primarily designed to provide an early indication of experimental design problems. Long-term differences in survival will be based on recovery of tagged adults in the ocean and river fisheries, and on returns to the hatchery. Given the large numbers of fish tagged and released, it is anticipated that differences in survival of 5% between passage modes will be detectable with an estimated recovery rate of 0.5%.

In 1987, the release sites (Figure 5) were: 1) upper turbine, 1 m below the ceiling of the turbine intake and immediately downstream from the gatewell (17B); 2) Lower Turbine, 1 m below the lowest elevation of the extended traveling screen in the turbine intake immediately downstream from the gatewell (17A); 3) bypass, at the surface of the downstream migrant bypass channel adjacent to gatewell 17B; and 4)

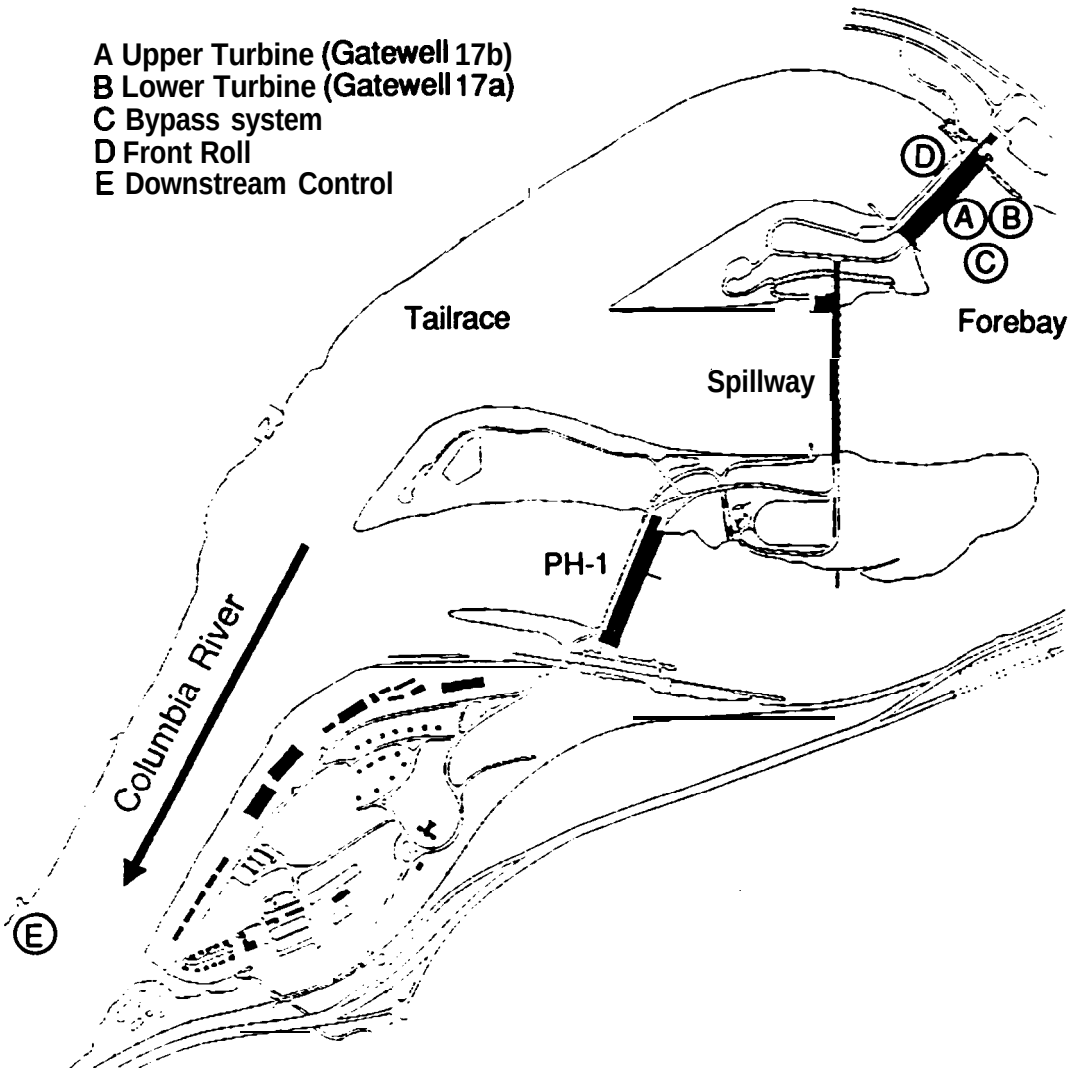


FIGURE 5. Release Location for Bonneville Dam Fish Passage Survival Study (PH = powerhouse)

downstream control Washington shore at water surface, 2.5 km downstream from the second powerhouse. Fish were not released through the spillway because of insufficient flows during this drought year. Twenty releases were made during early morning darkness between 25 June and 19 July. Each release consisted of five groups of 20,000 fish in individually marked groups. With the extra fish available because spillway releases were not made, a total of about 460,000 fish were released at each site.

The experimental design for 1988 was modified from 1987 based on preliminary results from estuarine sampling. As a result of lower recovery rates for control fish than for treatment fish in 1987, the control release site was changed to a mid-river

location. Insufficient water for a spill again forced elimination of the spillway releases. In the second year, however, the extra test fish were used for an additional release location at the downstream side of the Turbine 17 discharge (front roll, Figure 5). This site was intended to allow a comparison of survival through the turbine and bypass routes and to isolate any effects from passage through the tailrace basin. Twelve releases of groups of about 30,000 fish each (individually marked) were made from June 27 to July 24. In total, about 360,000 fish were released for each treatment. In 1989, we anticipate the same procedures and release sites as used in 1988, with the addition of spillway release groups.

The test fish in this study are upriver bright stock, subyearling fall chinook salmon reared at the Oregon Department of Fish and Wildlife's Bonneville Hatchery. Brands and coded wire tags were applied to all treatment groups simultaneously. Marking stations were each dedicated to marking a specific treatment, and fish markers were rotated among marking stations every 4 hr. Samples of marked fish were collected during each 4-hr period to hold and evaluate for tag loss and brand legibility. Marked groups were held in hatchery raceways from 1 to 14 days, then transported by truck, tempered to Columbia River water, and released during early morning darkness. Water flows through the second powerhouse were initiated 2 hr before fish releases and maintained for 6 hr following releases.

The utility of recovering downstream migrant salmonids in the estuary and using recovery rates to estimate relative survival has been evaluated in several previous studies conducted by NMFS between 1966 and 1983. However, to make the transition between recovery rate and survival in this study, several assumptions must be made. Some of those assumptions are as follows:

- Release groups were identical except for the treatment (e.g., size, health, smoltification, and handling).
- Errors in mark application and identification were insignificant compared with treatment differences.
- Differences in release procedures among treatments had no effect on survival (e.g., release hose hydraulic head and exit conditions).
- Differences in release time and distribution into the tailrace had insignificant effect on survival, compared with treatment differences.

- Differences in vertical and lateral distribution within the river downstream of the control release site had insignificant effect on survival.
- Probability of recovery was equal for all treatments (groups were mixed).

We feel confident all these assumptions are being met. The preliminary results from the first 2 years of this study have already pointed to unanticipated problems associated with passage of fish through the second powerhouse fish bypass system and the tailrace section. As additional data become available over the next several years, it is anticipated that the results will allow us to better manage or improve fish passage at Bonneville Dam.

WORKING GROUP SUMMARIES

MODEL EVALUATION GROUP

Review of Models RELEASE, Fishpass, and Stochastic Fishpass

RELEASE: This statistical program estimates survival and dam capture probabilities from marked fish released into the Columbia River and collected at downstream dams. RELEASE describes a series of statistical models in which the survival and resampling parameters are estimated by the maximum likelihood method. It was specifically applied to estimate survival of fish passing Columbia River dams. The underlying model is simple and does not identify factors that affect survival. RELEASE uses no travel time information and does not model fish movement. RELEASE estimates survival parameters and cannot be used to estimate dam and reservoir mortality. RELEASE is a finished product implemented on IBM-compatible computers under the MS-DOS operating system (see D. Anderson's presentation under "Review of Survival Estimation Techniques" for further details).

Fishpass: was developed as a management tool to evaluate the effect of different management options on juvenile smolt survival. It describes the effects of water flow, project operations, and transportation on the survival of juvenile fish in the Columbia River. The survival is based on empirical relationships that have been estimated from survival experiments conducted in the Columbia River. Travel time is described by an empirical relationship with flow, and the spread of a group of fish as it moves down river is described by a hydraulic model (the Muskingum routing algorithm). Dam passage is described in terms of the fraction of a run that passes with spill through the turbines and through the bypass system. Allocation between spill and the other routes is determined by the percent of the total flow spilled. Mortalities are prescribed for each passage route.

The USACE and BPA have separate versions of the model. The USACE version models movement of juveniles through the Snake/Lower Columbia River system and contains a simple model for estuarine and ocean survival that roughly estimates adult fish survival. The BPA version includes the mid-Columbia projects and does not include the adult fish survival component. In the BPA model, river flows are predicted by the system analysis model that generates flow estimates according to water storage and regional power demands. Fishpass is a working management tool that is undergoing additional evaluation. Fishpass is written in FORTRAN and currently is set up to run on mainframe computers.

Stochastic Fishpass: This multivariant computer model describes the passage of juvenile fish through the river system in terms of probabilities of movement and mortality, The purpose of the model is to provide a framework in which to evaluate and support research on juvenile fish passage. The model describes fish movement from flow and fish behavior. Reservoir mortality is described by a predation rate dependent on travel time, predator density and activity, and dam mortality. As configured during the workshop, the model described mortality at each dam by a single number. Work is under way to describe dam passage by flow, environmental conditions, and species-specific characteristics of migrating stocks. During the workshop, a conceptual approach was outlined in which stress and fish condition dynamically after fish health, and this, in turn, affects the rate of mortality. The model has a user-friendly graphics interface that allows input of all parameters through the computer's mouse. Input information and passage histograms outputs are superimposed on a map of the Columbia River. The model is written in C and Suntools and runs under Sun Operating System 4.0 on Sun Microsystems workstations.

Evaluation of Survival Estimation Techniques

Several computer model exercises using Fishpass and Stochastic Fishpass were conducted to evaluate survival studies. With each model, the migration and survival of single releases of fish were computed using 1985 flow conditions. For Fishpass, using a standard range of parameters, survival of a group released from Lower Granite Dam to below Bonneville Dam was 16%. Using Stochastic Fishpass, survival of a group traveling between Asotin, above Lower Granite Dam, to below Bonneville Dam was 19%. Reservoir mortality was altered in both models, and the effect on survival past Bonneville Dam was determined. In Fishpass, mortality was reduced in one reservoir, and the effect on survival through the reservoir was determined. Using Stochastic Fishpass, model parameters were easily changed, and runs were made with many different parameter configurations. The model results demonstrated that Fishpass and Stochastic Fishpass gave similar results. Qualitative evaluations of the effects of parameters suggested incremental variations of flow on the order of 30 thousand cubic feet per second (kcfs) changed survival by a few percent. A change in the mortality of a single reservoir by 50% changes survival past Bonneville Dam by a few percent. Following the workshop, a more detailed analysis was conducted (Appendix A).

WORKING GROUP SUMMARIES

One goal of the model group was to evaluate the impact of assumption violations in the statistical program RELEASE. The approach was to generate capture history data with Stochastic Fishpass, which were used in RELEASE to calculate survival. Since survival in the model was known, it could be compared with survival and the estimated survival from RELEASE. A difference between the model survival and estimated survival provided a measure of the significance of assumption violations in RELEASE. The evaluation was completed after the workshop and suggested biases may occur in survival estimated with RELEASE (Appendix A).

Although the statistical uncertainty can be estimated for a given technique, model uncertainty still exists resulting from not knowing if the underlying model is correct. This model uncertainty can only be assessed by a comparison of survival estimates from different models. To illustrate the significance of this uncertainty, survival estimates from the direct and indirect estimator methods were compared using the PIT tag data from the 1987 Lower Granite survival study. The statistical uncertainty of survival estimated with either method was about 6%. The model uncertainty, represented by the difference in the two methods, was 15% (Appendix A).

The level of precision in water budget evaluation will, in part, depend on the sensitivity of survival to flow and the variance and bias in survival estimated from field studies. The workshop model exercise sewed to illustrate how biases can be evaluated by a comparison of different models and statistical estimators. The resolution of suwival in past studies was determined to be greater than 10%. The sensitivity analysis of the model suggested that an increase in the spring flow by 30 kcfs may increase survival by less than 5%. Thus, to a first order, it appears that by using techniques applied in past studies, the effect on survival of a 30-kcfs increase in flow would be difficult to quantify. The problem is compounded if other factors that contribute to survival are not quantified or accounted for.

Summary of Model Evaluation Group Results

- Computer models that predict suwival from underlying mechanisms can be used to evaluate the validity and uncertainty of statistical models that estimate survival from capture histories.
- Computer model sensitivity analysis suggests that small incremental variations in water budget, predator control, or dam mortality may change survival by a few percent.
- Significant uncertainty exists in the currently available suwivai estimates.

- Current survival estimates have sufficient uncertainty and variability to limit their use in evaluating the effectiveness of the Water Budget Program and other programs (e.g., predator control) on smolt survival research.

Model Evaluation Group Recommendations

The model evaluation group recommended that efforts be directed at improving survival estimation techniques and models that describe the flow-survival relationship. Methods currently used contain a high degree of uncertainty and have marginal use in resolving the effects of incremental increases in flow.

The feasibility and uncertainty of future survival experiments should be determined in the experimental design. Specifically, survival experiments based on existing statistical protocols should be planned and evaluated using mechanistic computer models that temporarily describe the movement and survival of fish in the river.

STANDARDS GROUP

Eleven participants met in this working group to discuss the standards that have been used in the past to conduct smolt survival testing. Standards used for evaluations in previous studies on smolt survival during downstream migration in the Columbia River Basin were reviewed, and standards for future survival studies were agreed to.

A list of standards was established in five areas: 1) field methods/facilities, 2) test design, 3) data analysis, 4) reporting, and 5) data management or storage. Some standards are being, or have been, applied to survival tests in the Columbia River Basin; others are considered necessary for the successful implementation of future survival studies. Standards that were discussed as current and future follow.

Field Methods/Facilities Standards

Current

- The handling of treatment and control groups should be equal before release.
- Too many brand types are being used. Confusion and biases exist in recognizing and recording some brand types and brand orientations This will be resolved to some extent with PIT tag technology. Where batch-brand testing with cold brands continues to be a test requirement, left/right differences in treatment and control should not be used, and some orientations (especially 2s and 4s) should not be used.

Future

- Fish condition must be known and reported throughout the test. Test fish should be of equal condition throughout the test.
- High grading of fish for branding should be eliminated. This comment was tempered by some to indicate a necessity to weed out some fish, especially at hatcheries. Temperament was accepted; however, there is strong sentiment against high grading.
- The test fish must represent the population of concern as closely as possible.

Test Design

Current

- Capture effort is an important element of test design.
- Capture of treatment and control fish must be equal.
- Re-release of marked captured fish is standard for tests using batch-marked test fish.

Future

- Equality in capture between treatment and control fish will not be as important a standard with the advent of more PIT-tag-directed experiments.
- The new standard should require the removal of marked fish from a test after it is captured unless the tag and the individual fish can be later identified (this is the case with PIT tags) or if low recovery rates and/or unacceptable removals of test populations is anticipated.
- PIT-tagged fish that are removed from a test or control group need to be identified and their fate reported.
- The sample error, experimental error, and methods used to estimate them have to be defined in the test design before testing.
- The level of precision required or desired must be defined in the test design.
- A clear definition of a replicate needs to be provided, in addition to the assumptions of the protocol.
- The test design should be set by a multidisciplinary team that includes biologists, statisticians, and hydrologists.

- Test designs should be tested and reviewed on RELEASE before tests are conducted in the field.
- When PIT-tags are used, a minimum of two collection sites are advised.
- With the advent of PIT technology, the size of replicate groups will be reduced by the probability of increased collection (capture) efficiency. Therefore, the number of replicate groups can be increased. The minimum number of replicates should be 5; 10 or more replicates are strongly recommended.

Data Analysis

Future

- Test results should be examined with more than one model. This is a recommendation for a systematic evaluation using different models, not a recommendation to indiscriminately evaluate data with all possible models.
- Past efforts at analysis have to be examined. These efforts will define past and future standards, which should include a review of assumptions, data plots, and passage histograms.

Reporting

Future

- All raw data from survival tests should be reported.
- Data from Tests 1, 2, and 3 (Burnham et al. 1987) should be presented.
- Coefficients of variance, sample error, experimental error, and confidence intervals should be reported.

Data Management

Future

- There should be a standard format to store all survival test data.

An additional goal specifically discussed by the standards group was identification of standards that could be applied to determine water budget effectiveness. This discussion was applied to two different questions: Could survival data be used to manage the water budget? Could survival data be used to evaluate the effectiveness of the water budget? The management approach implies that survival data can be used to determine which flows should be set . (Can we make a decision based on survival data?) The evaluation approach would use survival data to relate cause/effect

between river flow and smolt survival. (Can we use suwival data to determine if the water budget is working?)

The general consensus of the standards group was that survival data could not be used to determine water budget flows, and survival data could not be used to evaluate water budget effectiveness. Too many other variables affect survival to define a cause/effect relationship between flow and smolt survival. The standards group stated that it would be desirable to modify allocated flows for testing smolt survival. Flows should be manipulated as a means of controlling and determining smolt survival. This discussion and subsequent recommendation differ from the pessimism of the cause/effect discussion in that the group suggested that the water budget should be used as an experimental tool, rather than an observed condition during survival tests. It was acknowledged that agreeing to use the water budget as an experimental tool would be difficult or even impossible.

FUTURE DIRECTIONS GROUP

Thirteen members of the workshop group met to discuss the future direction of smolt survival studies, including technical and policy development needs. Three general goals were suggested for group discussion: 1) provide recommendations on the type of survival studies that can be conducted with existing facilities, 2) identify new approaches and additional facilities for improving survival estimates, and 3) identify survival estimation techniques that can be applied to determination of reservoir mortality and water budget effectiveness.

Need for Survival Estimates

Most individuals agreed that valid survival estimates were needed to improve parameter estimation and modeling efforts and to evaluate the effectiveness of the Council's Fish and Wildlife Program. Operations, mitigation, and system planning were identified as general areas where suwival estimates were needed. Specific areas identified as important under the Fish and Wildlife Program included the water budget, bypass options, reservoir management (predator control), hatchery effectiveness, and transportation. Other individuals expressed the opinion that an evaluation of the water budget was not contingent on accurate survival estimates. Written comments of the report draft expressed the opinion that the need for survival studies was ill defined. It was suggested that final judgment on the need and role of survival studies

depends on successful development of a theoretical framework that adequately defines the biological reality of survival and a determination of whether the necessary data can be acquired.

The group concerned themselves primarily with specific issues related to Fish and Wildlife Program evaluation, focusing on relationships affecting juvenile survival. The consensus was that existing models were not precise enough to assess the effectiveness of the water budget. The water budget was perceived as a management concept that did not equate with a simple flow/survival relationship, i.e., the system is too complex to isolate only flow.

Follow-on discussion was directed at the potential for development of a flow/survival relationship. Flow was one parameter that can be easily measured throughout the system. It is more difficult to get accurate information on most other parameters thought to affect smolt survival. However, there were some concerns relating to the use of flow values. For example, rate of flow change, timing of flows, velocity through a pool or reach, and location of flow measurements may all need to be considered in model design. it was also agreed that some minimum flow level may be needed for smolt survival. Some present models on survival are based on exposure time (flow x length or reservoir) and are not precise enough to satisfy investigators. Additional information on flow volume/time, velocity, and turbidity is needed for future models. An initial approach would be to relate survival to the flow/travel time relationship.

New Approaches and Additional Facilities

A life history approach to estimating survival was recommended. Experiments that use existing study groups with background information on condition/size at release, migration rate, contribution to commercial/sport fisheries, and to escapement at spawning grounds were favored. The group felt that an important link between in-river survival and adult survival needs to be made. However, there is too much noise in the system to depend on adult recovery (as an index) for management use. There is a need to obtain more information on mechanisms that get fish through the river and that contribute to estuarine/ocean survival. Estuarine and nearshore survival may be affected by migration rate and timing. the use of complete life history groups could assist sorting out of key variables influencing survival and adult return. Both wild and hatchery stocks need to be considered in this approach.

The group strongly supported the use of PIT tags to determine travel time and estimate survival of smolts. It was agreed that using individually coded tags would provide more precise estimates with fewer numbers of fish. A PIT tag detector for detection of juveniles passing Bonneville Dam was recommended, with additional detectors added at other dams as juvenile bypass facilities were built. A need for development of PIT tag detectors for adult salmon at fish ladders was also discussed.

Application of Existing Techniques

An overall evaluation of current approaches used to estimate survival was recommended. There was confusion among investigators regarding model assumptions and validity of results. Some studies appeared to satisfy study design assumptions, but data were variable. Other studies could not logistically coordinate releases, fish condition, etc., to satisfy the assumptions for analysis. The group suggested a separate study be funded to determine the appropriate application of available models, limiting assumptions, and relative sensitivity to estimates of reach, reservoir, and dam passage survival. This information would then be used to direct future study designs.

There was no support to re-evaluate historical data sets or to conduct comparative analysis using current models. Some summaries already -exist in the literature that discuss results of survival studies conducted to date. it was decided that new methods for improving collection efficiency did not need to be discussed. Investigators are aware of the need for these studies and are developing appropriate site-specific methods, when possible.

Future Directions Group Recommendations

The group felt that increased communication among working groups was needed to accomplish research goals. They realized that there may be competition or even conflicting needs between fisheries agencies for test fish. Coordination between transportation, reservoir mortality, and other passage studies is an essential component of future needs.

To summarize, four basic recommendations were given for future study:

- There is a need for a better mechanistic model, one that is life-history oriented and that includes more parameters. For example, average velocity may be a better parameter to include in estimations than daily average flow. Rate of flow increase and threshold flows are also considerations. More measures of fish

condition should be obtained during outmigration. For example, physiological indices of stage of smoltification could be determined at release and at several in-river capture locations. The group recommended concentrating on a flow/travel time relationship to get to a travel time/survival relationship (i.e., survival will be modeled as a function of travel time).

- There is a need to work with complete life-history groups to reduce the noise between relationships of operational/environmental parameters and fish survival. This would allow investigators to evaluate in-river survival (plus estuarine survival and adult return) in relation to release time, travel time, migration rate, fish condition, and flow. Stocks already under study should be used where survival data sets can be enhanced.
- Recommendations 1 and 2 could be accomplished by adding a PIT tag detector for juveniles at Bonneville Dam and PIT tag detectors to fish at other facilities if/when bypass systems are built. The group recommended the installation of adult detectors at existing fish ladders. The feasibility of this should be explored further.
- There is a need to proceed with model evaluation before survival estimates can be improved. This evaluation should include the three current/proposed models or approaches for determining fish survival, i.e., direct and release/capture (indirect), and epidemiology. The appropriate application, limiting assumptions, and relative sensitivity of each model should be determined. Is the theory sufficiently developed to apply? Also, is the model a reasonable approach from a logistics standpoint?

DAY THREE WRAP-UP SESSION

DAY THREE WRAP-UP SESSION

On the third day, remaining workshop participants assembled and discussed future directions and needs related to PIT tag facilities, alternative technologies to PIT tags, new approaches for improving survival estimates, use of survival measurements in multivariate evaluation of water budget effectiveness, and factors affecting survival of juvenile salmon and steelhead. Approximately half of the workshop participants remained for these discussions.

FUTURE DIRECTIONS AND NEEDS RELATED TO PIT TAG FACILITIES

The group discussed what future steps should be taken to evaluate the existing survival estimators. It was recommended that survival studies based on the protocol in Burnham et al. (1987) should be evaluated. Assumption violations should be investigated, and procedures for controlling fish physiological condition at release should be worked out in detail. The evaluation would be used to determine if survival studies based on RELEASE are practical.

Limitations of existing counting facilities and needs for future facilities were discussed. With the current facilities, survival studies using PIT tags are limited to three mark recovery sites: Lower Granite, Little Goose, and McNary dams. Measurements of system survival on the lower Columbia River cannot be conducted or evaluated properly without additional PIT tag facilities. A recommendation for placement of PIT tag facilities at additional dams was discussed and additional details later outlined in Appendix B.

ALTERNATIVE TECHNOLOGIES TO MARK FISH

Although future survival studies will emphasize the use of PIT tags, alternative technologies might be considered. For example, it was pointed out that rings on the otolith might be used as a tag to mark and age fish. The otolith forms discrete rings each day. The shading of the rings changes with water temperature and stress experiences during the day. Thus, it might be possible to mark individual groups of hatchery fish by exposing them to a pattern of temperature changes that would define a unique sequence of otolith rings much like bar codes used to mark merchandise in stores. The age and release location of fish groups captured at dams could then be determined by an otolith analysis.

NEW APPROACHES TO IMPROVE SURVIVAL STUDIES

Both the direct and indirect survival estimation methods ignore unique traits and travel times that individual PIT-tagged fish convey. These factors influence their

individual survival potentials and suggest a better estimator of survival can be developed based on information from individual PIT-tagged fish. A statistical technique that uses the case histories of individual fish has three advantages: 1) it provides more realistic analysis based on the responses of individual fish, 2) greater extraction of information is possible from PIT-tagged studies, and 3) the technique has greater logistical ease. Fish within a single release serve as both control and treatment fish in this epidemiological approach. Each fish contributes information about travel time and/or capture probabilities much like data in a regression analysis provide information on regression coefficients. Pre-release data on size or condition index of smolts can also be incorporated in establishing downstream survival relationships with this analysis. The anticipated benefits of this approach are an improved understanding of the fundamental relationships influencing fish survival that are masked by the group response techniques currently available. See Appendix C for more details.

RECOMMENDATIONS

The remaining group made four major recommendations in the wrapup session:

- A survival study based on the protocol in Burnham et al. (1987) should be designed. Assumption violations should be investigated prior to design of survival studies based on them, and procedures for controlling fish physiological condition at release should be examined. This evaluation would be used to determine if survival studies based on RELEASE are practical.
- The theory for an epidemiological approach be developed and evaluated. The study would include an uncertainty analysis using techniques outlined in the model group session.
- Installation of PIT tag facilities should be considered (based on specific studies and feasibility) at additional dams to improve survival studies.
- Natural biological tags such as otolith ring patterns or alternative technology should be considered for marking fish used in survival studies.

WORKSHOP RECOMMENDATIONS

WORKSHOP RECOMMENDATIONS

Specific recommendations for future research were made throughout the workshop. The following list summarizes the major recommendations put forward by speakers or in the working groups. The list was compiled by session moderators using written summaries developed during group discussions. Several participants left the workshop before the third-day wrap-up due to adverse weather conditions and prior commitments. Consequently, a complete review and discussion of all topics developed in the working groups was not achieved.

- As recommended by the futures direction group, and followed up during the third-day wrap-up discussion, an evaluation of a possible survival experiment based on RELEASE needs to be completed. Uncertainty in proposed experiments would be analyzed according to procedures outlined by the model group.
- As recommended by the future directions group, and followed up during the third-day wrap-up discussion, the theory for an epidemiological survival estimation method should be developed. Experimental protocol and uncertainty analysis of the method also need to be addressed.
- As recommended by the future directions group, and followed up during the third-day wrap-up discussion, PIT tag facility installations at additional Columbia and Snake River dams needs to be pursued. These should include detectors for juvenile fish at bypass facilities and development of technology needed to detect adult fish in fish ladders.
- As recommended by the standards group, standard methods for fish handling, data recording, statistical analysis, reporting, and data management should be established and adopted in future survival experiments.
- As recommended by the future directions group, development of life-history models needs to be initiated. These models should include additional parameters.
- As recommended by the future directions group, work should focus on both juvenile and adult salmon. Analysis of complete life-history groups is needed to effectively evaluate survival in relation to operational or environmental variables.

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APPENDIX A

POST-WORKSHOP MODELING EXERCISES TO EVALUATE SURVIVAL STUDIES

MODEL EVALUATION OF FACTORS AFFECTING SURVIVAL, BY JAMES ANDERSON

The purpose of this exercise was to demonstrate one method for investigating possible effects of control programs on survival. The approach was illustrated using Stochastic Fishpass. A standard scenario for fish released on the Snake River at Asotin was compared with scenarios where individual model parameters were altered to produce a 1% change in survival past Bonneville Dam. Daily flow from 1985 was taken as the base condition with other parameters set to give total migrant survival of 19%. The following individual model parameters were then changed:

- increasing the mid-Columbia River flow by 50,000 cfs during outmigration increased fish survival past Bonneville Dam to 20% and decreased median travel time to 7 days
- decreasing the predator population by 50% in John Day Reservoir increased survival past Bonneville Dam to 20%
- a delay in release of 1 day decreased survival past Bonneville to 18% because of the increase in predator activity with seasonal increase in river temperature
- a 5% change in dam mortality at John Day Reservoir increased survival past Bonneville Dam to 20%.

A summary of the effect of these model parameters on survival estimates is provided in Table A.1.

This heuristic exercise suggests that a number of factors can have about the same impact on survival. Although it is virtually impossible to hold other factors constant while another is individually manipulated, it appears impossible to measure a

TABLE A.1 ation of the Effect of Model Parameters on Survival

Altered Parameter	Location of Alteration	Change in Parameter	Survival Past Bonneville
Standard Run	---	normal	19%
Increased Flow	Columbia	+50 Kcfs	20%
Predator Removal	John Day	-50%	20%
Delayed Release	Asotin	+ 1 day	18%
Dam Mortality	John Day	-5%	20%

one-to-one correspondence between a specific factor and survival unless that factor can be sufficiently altered to exceed the impact of the variation of other factors. The numbers in Table 1 are given for illustrative purposes to demonstrate how a model can be used to evaluate the effect of management programs on juvenile survival. They do not represent a precise analysis of the water budget or other management programs.

EVALUATION OF RELEASE MODEL ASSUMPTIONS

Concern has been expressed that assumptions in RELEASE (Burnham et al. 1987) might be significantly violated for pool and reach survival studies, where test and control fish are released at different locations and times. Important assumptions that need to be evaluated include:

Assumption 6	All releases and recaptures occur in brief intervals of time.
Assumption 7	Fate of individual fish independent of fate of other fish.
Assumption 8	Data are statistically independent over lots.
Assumption 9	Statistical analysis of the data are based on the correct model.
Assumption 10	Treatment and control fish move downstream together.
Assumption 11	Capture and re-releases of fish have the same survival and capture rates as fish not captured.
Assumption 12	All fish have the same survival and capture probabilities.

Assumptions on RELEASE can be evaluated with capture histories generated with independent models, including SIMULATE, a Monte Carlo simulator to generate capture histories (Burhnam et al. 1987) and a version of Stochastic Fishpass.

To investigate if violations of Assumption 6 resulted in significant biases in RELEASE estimates of survival, a complete capture history generated with Stochastic Fishpass was analyzed with the H1 Phi model of RELEASE. In the model scenario, a treatment group was released in Asotin, and a control group was released in the Lower Granite forebay. The timing of releases were adjusted to mix the treatment and control groups at the dams. Collections were made at Lower Granite, Little Goose and McNary dams. A complete capture history of the model-generated data is given in Table A.2, and a comparison of results from the model and RELEASE are given in Table A.3. From RELEASE, the ratio of control and treatment group survivals and the capture probability at Lower Granite Dam are close to the actual values generated with

Stochastic Fishpass. All estimates from RELEASE are within 10% of the actual values generated from the model. The small bias may result from a violation of Assumption 6. In Stochastic Fishpass, fish crossed the dams over periods ranging in duration from 6 to 37 days. RELEASE assumes the groups pass a project in 1 day. This exercise illustrates how the effects of model assumption violations can be studied with mechanistic models. As was pointed out by D. Anderson, and supported by this exercise, the effects of assumption violations are minimized when survival is expressed as the ratio of the treatment and control group survivals.

Model Assumptions 6 and 10 can be evaluated with mechanistic models and data currently available. The rudimentary analysis illustrated suggests that these assumptions may not significantly affect the ratio of treatment and control group survivals, although the absolute values of the estimates exhibit some biases. Assumptions 7, 11, and 12 relate to the behavior of fish and their capture probabilities. These factors have not been described quantitatively, but qualitative observations, discussed by Tom Berggren, suggest that they may be violated. The effect on survival and their ratios are yet to be determined.

TABLE A.2. Complete Capture History Generated from Stochastic Fishpass. Treatment group released at Asotin. Control group released in Lower Granite Dam forebay.

Capture	Treatment				Control			
History	Asotin	Granite	Goose	McNary	Asotin	Granite	Goose	McNary
1000	8862				8220			
1100		595				928		
1110			48				75	
1010			369				579	
1111				2				3
1001				99				156
1101				13				20
1011				13				20

TABLE A.3. Survival and Capture Probability of Groups Through Lower Granite Reservoir from Model and Statistical Estimation. Lower 95% and upper 95% represent 95% confidence intervals.

	Treatment Survival	Control Survival	Survival Ratio	Capture Probability
Stochastic Fishpass	0.60	0.98	0.608	0.10
RELEASE	0.57	0.89	0.639	0.11
Lower 95%	0.49	0.76	0.595	0.10
Upper 95%	0.65	1.02	0.684	0.13

UNCERTAINTY IN SURVIVAL ESTIMATES

Currently, survival can be estimated with two approaches, the direct and indirect methods. A great deal of variability and uncertainty lies in both approaches. This is illustrated in Table A.4, showing survival in Lower Granite reservoir estimated using data from the 1987 survival study (Giorgi and Steuhrenberg 1988). Survival varies significantly between the two methods and between releases. Within a method, survival varies by about 6%, and between methods it varies by about 15%.

TABLE A.4. Lower Granite Pool Survival Estimates from Two Methods Using Data from Giorgi and Steuhrenberg (1988)

Release Site	Indirect(a)	Direct(b)
Asotin No. 1	0.72	0.88
Asotin No. 2	0.69	0.83
Asotin No. 3	0.74	0.85

(a) Indirect method, recovery at Little Goose only no spill.
(b) Direct method, Lower Granite collection efficiency = 0.338 (Sims et al. 1984).

APPENDIX B

CURRENT FACILITY LIMITATIONS FOR STUDIES AFFECTING SURVIVAL

FACILITY LIMITATIONS FOR CONDUCTING SURVIVAL STUDIES. JOHN R. SKALSKI

This appendix describes how survival studies are limited by existing facilities. It is not a recommendation for installation of new facilities, and the scenarios may contain facilities not planned or in operation.

FACILITY LIMITATIONS

Although it is anticipated that survival studies based on PIT tags can considerably improve estimates of migrant survival, the application is limited by current facilities. The possible facility configurations discussed here will include PIT-tag recorders and slide gates that return tagged fish back into the river at Rock Island, Lower Granite, and Little Goose dams and a PIT-tag detector at McNary Dam. Two survival study scenarios can be envisioned with these facilities:

S#1 nario

A single release of PIT-tagged fish at a site above Lower Granite Dam, say Asotin, could be performed. From the release, the capture history data would provide:

- survival estimated from Asotin to Lower Granite Dam
- survival estimated from Lower Granite Dam to Little Goose Dam
- the joint probability of surviving from Little Goose Dam to McNary Dam and being recaptured at McNary.

Scenario #2

A single release of PIT-tagged fish at a site above Rock Island Dam, say Wells Dam, would provide capture histories for:

- survival estimated from Wells Dam to Rock Island Dam
- the joint probability of surviving from Rock Island Dam to McNary Dam and being recaptured at McNary.

The above scenarios indicate that, with the inclusion of slide gates on the present facilities, it is only possible to obtain survival estimates in the upper reaches of the mid-Columbia and Snake rivers. This also assumes that collection efficiency estimates are available. In addition, the facilities provide limited capture histories that can only be used with the weaker survival models given in RELEASE.

To obtain survival estimates in the lower Columbia and improve the estimates of survival on the upper reaches, additional facilities are required. Ideally, these would include:

- slide gate at McNary Dam
- addition of PIT-tag detector at John Day and/or Bonneville dams
- additional PIT-tag recorder and slide gates at a dam between Rock Island and McNary dams
- PIT-tag detector at Jones Beach.

Although not recommended because of low statistical power, a single recovery site is sufficient for performing paired releases to estimate turbine/facility mortality. By using PIT-tag recorders at the next downstream dam, a basic turbine mortality effect could be evaluated at

- Lower Granite Dam
- Rocky Reach Dam
- Ice Harbor Dam
- Priest Rapids Dam.

APPENDIX C

EPIDEMIOLOGICAL APPROACH TO ESTIMATION OF SMOLT SURVIVAL

ALTERNATIVE SURVIVAL ANALYSIS. BY JOHN R. SKALSKI

The establishment of smolt survival relationships using either the direct or indirect estimation technique are based on a two-stage analysis. In the initial stage, the overall survival rates of smolt within brand or PIT-tag release groups would be estimated. Then, in the second stage of analysis, these overall survival estimates would be regressed against average conditions during their outmigration. This general approach can be insensitive in identifying important survival relationships because of the use of estimated survival rates and exposure conditions, which have been averaged across the individuals included in a release group.

With PIT-tagged fish, valuable information on survival relationships would be needlessly discarded using current mark-recapture models. In the existing models, all tagged fish are assumed to have independent and identical per period probabilities of survival. In other words, the smolt are conceptualized as behaving as classical ball and urn models. As such, the fate of a smolt release is modeled as a product of independent and identically distributed Bernoulli trials (e.g., flips of a coin). Tag-recapture models, however, are capable of incorporating much more information about the release condition and fate of the individual smolt.

A fundamental change in the statistical theory of tagging studies is needed to incorporate the case histories of the individually PIT-tagged smolt into the design and analysis of survival studies. New statistical models are needed that would permit the probabilities of survival to vary among smolt within a cohort as a function of their individual traits. For example, the individual travel times of smolt or their condition index at the time of release could be related to their subsequent downriver fates. The anticipated result will be statistical techniques more sensitive to shifts in survival rates and a greater understanding of the mortality processes acting on the outmigrants. Indeed, the effect of these new fisheries assessment techniques will be analogous to the benefits epidemiological studies have had in understanding human health effects. The assessment of survival relationships will no longer have to rely upon detecting shifts in the mean response of cohorts to environmental change. Rather, the assessment can be based on how the fate of individual smolt is influenced by varying release and outmigration conditions.

These statistical techniques, which would use the case histories of individual fish, have three advantages over existing survival methods: 1) they provide more

realistic analysis based on the unique response of individual fish, 2) great extraction of information is possible from the PIT-tagged studies, and 3) these techniques have greater logistical ease. Fish within a single release serve as both control and treatment fish in this epidemiological approach. Each fish contributes information about travel time and/or capture probabilities much like each datum in a regression analysis provides information on regression coefficients. Consequently, survival relationships can be established with the information from the PIT-tag data of a single release. In so doing, this epidemiological approach to survival analysis also avoids the problems of confounding changes in river conditions and release characteristics with shifting survival rates. All these advantages favor the ability to establish survival relationships that have been masked by the group response techniques currently available.

The essential aspect of the statistical models is the ability to allow individual smolt to have unique survival potentials related to their individual traits, while at the same time relating the survival rates of the smolts within a cohort. This characteristic of the statistical analysis is accomplished by assuming a common underlying model shared by all smolt, which relates their survival to prerelease and postrelease attributes. For example, survival of the jth smolt of a release group in the ith reservoir (Sm) could be modeled as

$$S_m = S e^{a_i + b_i c_i}$$

where

- S = baseline su rvival rate
- a_i = effect of the ith reservoir on survival
- b_i = regression coefficient associated with the relationship between a smolt's survival in the ith reservoir and the jth's smolt's condition index upon release
- c_i = condition index for the jth smolt upon release

based on the concept of proportional hazards. The subsequent survival analysis is then based on a product of multiple Bernoulli trials assumed to be independent among

smolt, but unique for each smolt. The linkage between the independent survival probabilities is the common form of the parameterization and the shared regression coefficients among smolt.

The proposed survival analyses, with the existing indirect survival estimators using PIT tags presuppose the eventual existence of PIT-tag decoding devices and flip gates on Columbia/Snake river dams. Part of the proposed research, therefore, includes identification of future PIT-tag facilities needed for successful survival investigations.

APPENDIX D

WORKSHOP SCHEDULE

TUESDAY, JANUARY 31, 1989

(Afternoon/Evening)

- Arrive Friday Harbor
- Go to main laboratory for room assignment
- Buffet Dinner 5:00 - 7:00 p.m., Conference Hall

WEDNESDAY, FEBRUARY 1, 1989

- Breakfast 7:30 - 8:30 a.m.

(Morning Session 8:30 am., Conference Hall)

- Introduction. J. Anderson
- Importance of survival studies in the Columbia River Fish and wildlife Program from different agency perspectives. Olney, Smith, Mundy, McConnaha, Athearn, Nason
- Review of survival estimation techniques:
  Program RELEASE. D. Anderson and Burnham
  Fish Passage Center Experiences in Conducting Survival Studies using the Indirect Method. Berggren
  A Review of the Indirect and Direct Methods and Collection Efficiency Studies used for Estimating Smolt Survival. Giorgi
- Lunch 12:00 - 1:00 p.m., Conference Hail

(Afternoon Session)

- 1987 Lower Granite Survival Study. Giorgi
- Mid-Columbia Survival Studies. Hays
- Juvenile Salmon Survival Study at Bonneville Dam. Dawley
- Dinner 6:00 - 7:00 p.m., Conference Hall

(Evening)

- Discussion. Group

THURSDAY, FEBRUARY 2, 1989

- Breakfast 7:30 - 8:00 a.m.

(Morning Session 8:30 a.m., Conference Hall/Apartments)

- Divide into groups for model evaluation, study standards, future directions.
- Generate capture history data sets with computer models, and estimate survival from capture histories. Model Evaluation Group
- Discuss standards used in survival studies (cost, time, assumption violation, statistical robustness, application to decision making). Standards Group
- Discuss future directions (Do we need survival studies; if so, are next steps in technical or policy development?) Future Directions Group
- Lunch 12:00 - 1:00 p.m., Conference Hall

(Afternoon Session, Conference Hail/Apartments)

- Continue group discussions: Model Evaluation Group, Standards Group, Future Directions Group
- Discussion of results of group discussions. Group
- Dinner 6:00 - 7:00 p.m.

(Evening Session, Conference Hall)

- Discussion of results. Group

FRIDAY, FEBRUARY 3, 1989

- Breakfast 7:00 - 8:00 a.m.

(Morning Session 8:30 a.m., Conference Hall)

- Wrap-up session: Discuss future approaches and steps for their implementation. Group
- Lunch 12:00 - 1:00 p.m.
- End Workshop

Introductory Materials

- Proceedings of the **Reservoir Mortality Workshop,** April 1987.
- Design and Analysis Methods for Fish **Survival** Experiments Based on **Release**-Recapture **(Burnham** et al. 1987).
- Statistical evaluation of **smolt** monitoring program at **McNary** and John Day dams **(Skalski** 1988).
- Lower Granite Pool and Turbine **survival** study, 1987. Giorgi and **Stuehrenberg**. Annual Report of Research to BPA.
- Mid-Columbia survival studies, **1980, 1982,** and 1983. (PNL, Chapman & Associates, **Parametrix).**

APPENDIX E

PARTICIPANT LIST

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Mr. Frank Young
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Portland, OR 97207

*Provided input for the wrap-up session; attended first day only

APPENDIX F

WORKING GROUP MEMBERS

Model Evaluation Group

J. Anderson, Moderator
K. Burnham
B. Tanovan
M. Fiiardo
W. Maslen
J. Geiseiman
J. Skalski
G. Swartzman
J. Petersen
R. Hinrichsen
A. Giorgi
T. Nigro
N. Schumaker

Standards Group

D. Neitzel, Moderator
J. Williams
E. Dawley
B. Sandford
J. Ruff
T. Berggren
P. Poe
R. Boyce
S. Hays
D. Rondorf
D. Anderson

Future Directions Group

D. Dauble, Moderator
P. Mundy
C. McConnaha
J. Osbom
S. Smith
F. Young
D. Nason
M. Deli
F. Olney
C. Simenstad
J. Atheam
D. Johnson

APPENDIX G

COMMENT LETTERS AND RESPONSES TO COMMENTS

APPENDIX G

COMMENT LETTERS AND RESPONSES TO THE COMMENTS

A comment draft of these proceedings was sent for review to 31 people who either participated in or had direct interest in the Smoit Survival Workshop. Review comments were received from 13 people. Comments included letters with specific points, mark-ups of draft text, and telephone calls. Formal comment letters were received from:

- David Anderson, Colorado State University
- Phil Mundy, Columbia River intertribal Fish Commission
- John Williams, National Marine Fisheries Service
- James Peterson, U.S. Fish and Wildlife Service
- Dennis Rondorf, U.S. Fish and Wildlife Service
- Stephen Hays, Cheian County Public Utility District
- Michele DeHart and Malcolm Karr, Fish Passage Center
- Fred Olney, U.S. Fish and Wildlife Service
- Raymond Boyce, Oregon Department of Fish and Wildlife

Additional comments of mainly editorial nature were informally submitted by four people:

- Mike Dell, Grant County Public Utility District
- Al Giorgi, National Marine Fisheries Service
- Earl Dawley, National Marine Fisheries Service
- Dick Nason, Chelan County Public Utility District

All comments were considered, and the text was revised, where appropriate. Copies of the formal letters and responses to their suggestions and/or criticisms are contained in this appendix. Because most comments were not listed in a uniform format, an attempt was made to extract the main point of each relevant remark. in several cases, comments were similar enough that a group response directed at a general comment was provided. The response indicates how the remarks were addressed in the revised report. There was no attempt to respond to comments that were not

specifically addressed to this report, although general comments and suggestions were noted.

Comment- Attendance at the last day's wrapup session was limited because many people left the workshop early. The text should include a list of those attending the last day's discussions and indicate that the written summary did not represent a consensus of all workshop participants. (Peterson, Rondorf, DeHart and Karr, Olney, Boyce)

Response- A sudden, unusually severe winter storm caused a power outage on San Juan Island and resulted in a major disruption of transportation systems. Consequently, many people left early because of concern for the welfare of their families and homes, and/or because of prior commitments. The revised text reflects the weather problems, indicates which organizations were represented in the final session (page ix), and acknowledges that results of the wrapup session do not represent a consensus of all workshop participants.

Comment- The material contained in Appendix A is not consistent with the procedures recommended in Burnham et al. (1987). Additionally, there are several examples where material appears missing (i.e., model inputs, discussion of model uncertainty), and conclusions seem preliminary (i.e., model bias). Finally, it should be made dear that appendix A was an heuristic exercise, rather than an evaluation of all available management options. (D. Anderson, Petersen, Rondorf, Olney)

Response- The model exercise (on which Appendix A is based) was revised to conform to suggested methods, using a treatment and a control group. The new model results are included in the revised Appendix A. Additional discussion of model uncertainty and bias have also been provided. However, a complete description of all flow variables was not included because the author felt it was not warranted. Appendix A was presented as a demonstration exercise only. The revised text indicates that it was not intended to evaluate all management options, but rather to describe an approach to such an evaluation.

Comment- Appendix B contains recommendations for placement of PIT tag detectors at several locations that appear impractical. The determination of required facilities should be linked to specific study designs, although there appeared to be general agreement that detectors should be placed at Bonneville Dam. (Rondorf, Olney)

Response- The discussion in Appendix B was presented to indicate where PIT tag facilities should be placed if the application of PIT tag technology is to be expanded. The overall group consensus was that additional facilities are needed to monitor smolt survival and movement. More specific recommendations will be developed through the Council's Fish and Wildlife Program.

Comment- It should be made clear that Appendix C (epidemiological approach) is not new, but an extension of existing theory. Application of the epidemiological approach to smolt survival studies in the Columbia River should be considered, but must be carefully evaluated. (D. Anderson, Olney)

Response- We agree that the proposed approach represents an extension of current theory. The appendix represents an alternative approach to that presented in the AFS monograph. Although these models are not new, their application to the Columbia River and smolt survival estimates is novel. We retained use of the term "epidemiological" because it reflects the workshop discussions, but with the concern that our use may perpetrate its application to this approach. The intent of this appendix was to provide a description of the approach for estimating survival, not to sell the epidemiological method as the best or only approach.

Comment- There is a lack of attribution of concepts and opinions to the editors and to individual participants. It is also unclear where some of the recommendations were derived from. (Petersen, Mundy, Boyce)

Response- The foreword and other sections of the report were revised to indicate the role of workshop moderators in development of the recommendations and other material in the report. The text was revised to indicate the affiliation and approximate number of participants present during the group discussions and the day three wrap-up session. However, it was not possible to identify the source of individual opinions. The list of recommendations was synthesized from written material generated during group discussions (standards and futures groups) and passed out to remaining participants for discussion on the third day of the workshop.

Comment- There was disagreement with certain statements or recommendations that were presented as group consensus. In some cases, specific discussions or key

recommendations were apparently deleted from appropriate sections of the report. (Petersen, Rondorf, Boyce)

Response- The following changes were made: 1) Model Group Summary- The text was revised to indicate a more general recommendation for the planning and evaluation of future survival experiments. In addition, the recommendation on the use of multivariate analysis for evaluating effectiveness of the water budget was incorrectly stated and has been deleted; 2) Standards Group Summary- The text was revised to include a standard that considers replication and the assumptions for testing;
3) Future Directions Group Summary- Our notes indicate a group consensus was reached concerning the need to proceed with model evaluation before survival estimates can be improved.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Fisheries Center
Coastal Zone and Estuarine Studies Division
2725 Montlake Boulevard East
Seattle, Washington 98112-2097

June 1, 1989

Dr. Dennis Dauble P7-50
Battelle, Pacific Northwest Laboratories
P.O. Box 999
Richland, Washington 99352

Dear Dennis:

I have made my comments on the enclosed draft Proceedings of the Smolt Survival Workshop. If they are unclear or you would like additional expansion of them, please give me a call at (206) 442-4908.

Sincerely yours,

John Williams

Enclosures

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Columbia River Coordinator
9317 Highway 99. Suite I
Vancouver, WA 98665

June 19, 1989

Dr. Dennis Dauble
Battelle, Pacific Northwest Laboratories
P.O. Box 999
Richland, Washington 99352

Dear Dr. Dauble:

I have reviewed the draft workshop proceedings and offer the following comments.

Page 9, 1st paragraph lines 9-11.

This sentence should read: Many factors have an effect on juvenile survival and these are expected to change in the future, for example, as we implement programs to control predation, install and improve bypass facilities, and improve fish condition.

Page 55, 2nd paragraph.

There are a number of statements in the workshop summary like, "Individuals agreed that valid survival estimates were needed..." that are made without adequate qualification. Final judgment on the need and role of survival estimates is dependent upon: 1) the successful development of the theoretical framework (mechanistic model) which adequately depicts biological reality and includes all of the parameters affecting survival, 2) a determination of what data are necessary, and 3) a determination of whether it is practical to acquire all the necessary data. Improving our ability to estimate survival is only important to pursue if we can measure the other key parameters and sort out how all the various factors affect fish survival.

Page 57, Recommendation of Future Directions Croup

I don't see the relationship between the installation of PIT-tag detectors and the development of a better mechanistic model. PIT-tag detectors will not help sort out the influence, for example, of predation. project operations, and fish condition on fish survival. Physiological condition of PIT-tagged fish cannot be determined at capture locations because of the inability to sacrifice the fish. There is no way of knowing whether a PIT-tag detected fish passed through the turbines or went over the spillway at previous dams unless there is no spill. Accurate estimates of the amount of mortality due to predation will be impractical to acquire and difficult to compare between years because, even if the predator population remained constant in site. there will be large between year variation in predation due to differences in

temperature and predator activity, differences in the magnitude and composition of the prey population, and other factors that influence predation between years. Within year differences in predation mortality between reaches or pools and over tine will be even more difficult to estimate.

Pages 61-63.

It should be explained that the recommendations on the third day do not reflect a consensus of all of the participants because many of us had to leave early. Without being present it is impossible to comment on how accurate the summary depicts the proceedings on the third day. However, I would offer that there is no apparent logical sequence to the activities listed. It is more of a potpourri of activities rather than a step by step process.

The first step is to develop a better mechanistic multivariate life history model. Once everyone agrees the mechanistic model adequately depicts biological reality, as we know it, then we can proceed with evaluating whether methods like the epidemiological approach supply the necessary data. A determination of the facilities required would follow identification of methods and study design.

Appendix A

An interesting heuristic exercise that shouldn't be taken too seriously,

Appendix B

It is not practical to use PIT-tag detectors at Jones Beach because of the small number of tagged fish that would be captured. Again, the determination of which facilities are required should be tied to specific study designs although it is generally agreed that a PIT-tag detector is needed at Bonneville Dam for monitoring and other purposes.

Appendix C

We shouldn't be oversold on this approach. One problem that has been identified is that, unlike other epidemiological studies, we have no opportunity to examine the fish that die and the fish that are examined are only those that are guided and enter the collection facilities. The epidemiological approach has many of the same problems as existing methods because of the complexity of the relationships involved and the difficulty in designing a study where the marked fish are truly representative of the migration. Again, we should develop the mechanistic model first and then determine which methods to pursue.

Thank you for the opportunity to comment.

Sincerely,

Frederick E. Olney
Columbia River Coordinator

United States Department of the Interior

FISH AND WILDLIFE SERVICE

National Fishery Research Center
Columbia River Field Station
Star Route
Cook, Washington 98605

June 2, 1989

Dr. Dennis Dauble P7-SO
Battelle, Pacific Northwest Laboratories
P.O. Box 999
Richland, WA 99352

Dear Dennis,

Enclosed are a few review comments on the "Proceeding of the Snolt Survival Workshop" draft. Most of my comments are on the "Model Evaluation Group Summary" since I participated in that group and many other portions of the report are straight-forward summaries of presentations.

In general, the report appears complete, easy to read and a good summary of the proceedings. There are many typos and misplaced words in the draft that I assume will be corrected before publication. Also, I think it would be appropriate to provide a list of participants who contributed to the recommendations in the wrap-up session, since many people could not stay for the final session because of the weather.

Comments on "Model Evaluation Group Summary" (and Appendix A)

Review of the various models was adequate and summarized the objectives, parameters and operation of the models.

Discussion of the water budget evaluation on pages 48 and 49 should be combined for clarity. Also, care should be taken in discussing *percent change in mortality" versus "the change in percent mortality" -e.g. in Appendix A (page A.1.), "Increasing the flow by 50,000 kcfs . . . increased fish survival past Bonneville Dam by 20%" should say "to 20%". The importance of other factors that may affect mortality besides the water budget is important and is mentioned on page 49.

The brief evaluation of RELEASE methodology on page 49 and in Appendix A, and the conclusion that a bias may exist, seems preliminary and more work would be required to make any firm conclusions in this area.

Appendix A does not appear to contain a discussion of "model uncertainty" that was nentioned on page 49. This should be clarified, or discussion added in Appendix A if it is missing.

The summary and recommendations of the model group appear to be well presented, although I do not remember specific discussion in the group about the epidemiological approach for estimating survival.

The heuristic exercise in Appendix A to denonstrate the use of a model in examining management options is useful, as long as it is clear that the exercise is not meant to be a complete evaluation of any options, which is stated by the authors.

I hope these comments help in revision of the proceedings.

Sincerely,

James H. Petersen, Ph. D.
Fishery Biologist

cc: Fred Olney

cr

United States Department of the Interior

FISH AND WILDLIFE SERVICE

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June 5, **1989**

Dr. Dennis Dauble **P7-50**
Battelle, Pacific Northwest Laboratories
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Richland, WA 99352

Dear Dennis:

Following are my comments on the draft report entitled, "Proceedings of the Smolt Survival Workshop". I believe the draft adequately and fairly reflects the discussions during the workshop. The third day wrap up session must have had a relatively low number of participants. If so, that should be mentioned as the wrap up section is presented in such a way as to imply a workshop consensus. while the three major recommendations from the wrap up session on page 62 are fairly general and may represent a consensus, the material presented in Appendices E and C may not.

Most of my comments are on the summary for the Standards Group because I was a participant in that group discussion.

P 52 "Test Design": Dr. David Anderson suggested that one of the standards for the future be the development of a theoretical basis for the direct method if this method is to be used in the future. Burnham et al. 1987 provides such a basis for the batch marked and uniquely marked animals. The futures directions group apparently came to a similar conclusion according to recommendations given on P viii item 4 and P 58 item 4.

P 52 L 20: One of the standards not listed was a clear definition of a replicate with a listing of the assumptions and detailing of the protocol for replicates. A participant noted that some past experiments (Long et al. on the Snake R.) can not be reanalyzed using new models because of the methods of replication. Following that point was a discussion of the effort a research biologist had to go to create a replicate, e.g. lifting and replacing release hoses, different tanks or divided tanks, and if uniquely marked individuals of two lots could commingle.

p 53 L 14: "The general consensus of the Standards Group" is the beginning of a difficult to understand paragraph. I believe that the consensus is better captured by a sentence on P 55 Para 3 "The Water Budget was perceived as a management concept that did not equate with a simple flow/survival relationship". However, this pessimism did not extend to future work on the flow/survival relationship. A participant pointed out that a standard

for flow/survival research would be a fairly wide range of flows to better define a relationship. A potential problem is that the research will result in most data at moderate flows and not very much at the low flow regimes. Dr. John Williams then mentioned using the Water Budget as a possible experimental tool. The part not included in the draft report are the comments about reality and the difficulty of getting all parties to agree to creating very low flows that will likely result in the low survival of smolts migrating at that time. In summary, using the "Water Budget" as an experimental tool is not authorized and may be difficult to reach an agreement among all concerned parties.

P 63 item 4: For numerous reasons, the choice of otolith ring patterns may not be a particulary good example of an alternative technology to mark fish snolts in the Columbia River. However, the consideration of alternative technologies is desirable. The sentence on P viii para 2; "New tagging methods should be explored based on natural biological tags such as otoliths" should advocate the use of alternative technologies not just the use of otoliths.

A.1 "Model evaluation of factors affecting survival" If you have space to provide the output you have space to provide the inputs. P A.1 L 6 "Flow conditions for 1985 were taken as the base condition" is a pretty vague description of input. The Standards Group developed several standards aimed at putting an end to the practice of not providing enough detailed information in the survival estimate research. If inputs can not be provided, then the results should be omitted.

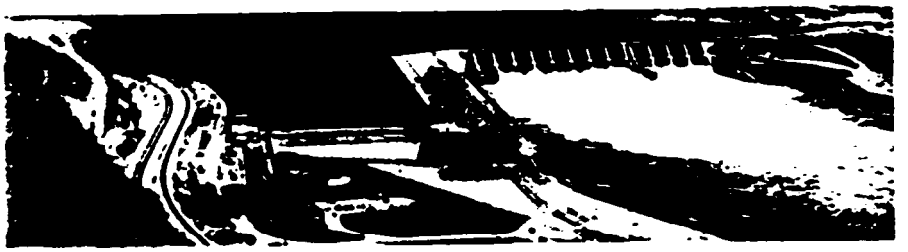
Appendix B: A recommendation for PIT tag detectors at Rock Island Dan, John Day Dam, and Jones Beach among other sites may surprise some participants. The recommendations in Appendix B seem of little value because they recommend detectors at almost all dams. Apparently the Futures Directions Group recommended Bonneville Dam (P 57 item 3). Since this seems to be more specific (not necessarily more practical) perhaps item 3 on page viii of the Executive Summary should contain that recommendation rather than the generic statenent used.

Sincerely,

Dennis W. Rondorf
Fishery Biologist

cc: Fred Olney
Bill Nelson

cr



Public Utility District No. 1 of Chelan County

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June 5, 1989

Dr. Dennis Dauble P7-50
Battelle, Pacific Northwest Laboratories
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Dear Dennis,

I have enclosed some minor factual corrections and corrected some spelling errors (my last name) in the draft report "Proceedings of the Smolt Survival Workshop". The corrections are marked in red on the applicable pages of the draft report.

Thank you for the opportunity to comment. The report very nicely summarizes the results of the workshop and concisely covers all the major points. Good Job.

Very truly yours,

Steven Hays
Fisheries Biologist

Enc.

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June 12, 1989

Dr. Dennis Dauble
Battelle, Pacific Northwest Laboratories
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Richland. WA 99352

Dear Dr. Dauble:

AS you know, Dr. Margaret Filardo and Mr. Tom Berggren of the Fish Passage Center staff participated in the Bonneville Power Administration workshop addressing smolt survival in February 1989. The staff has reviewed the draft workshop proceedings and developed the following comments.

The presentation given by Tom Berggren on the first day of the workshop is reflected accurately in the draft proceedings, and the changes that he suggested in the earlier draft have been incorporated.

Our greatest concern regarding this draft is the presentation of recommendations resulting from the third day of the workshop. The draft proceedings are misleading, in that the unknowing reader is led to believe that the recommendations are the result of the workshop and that all workshop participants support those recommendations. In reality, the recommendations were developed and are supported by relatively few individuals who were present on the third day of the workshop. The Fish Passage Center staff participants were not present and did not participate in the development of the recommendations. The proceedings should be modified to identify the actual individuals who developed the recommendations, so that readers realize the recommendations were not developed from the workshop as a whole.

The recommendations contained in the proceedings do not seem to have resulted from either the presentations on the first day or the work group sessions on the second day. They appear to be solely the result of the third day of discussion, which had limited participation. In general, we believe the proceedings would benefit from elimination of editorializing, particularly relative to conclusions and recommendations.

We appreciate the opportunity to comment on the draft.

Sincerely,

Michele DeHart
Fish Passage Manager
Fish & Wildlife Agencies

Malcolm H. Karr
Fish Passage Manager
Columbia Basin Tribes

cc: FPAC
Pat Poe

299-89.*

Colorado Cooperative Fish & Wildlife Research Unit

201 Wagar Building
Colorado State University
FORT COLLINS. COLORADO 80523
Phone: 303/491-5396
303/491-6942

Dr. Dennis Dauble P7-50
Battelle, Pacific Northwest Labs
P.O. Box 999
Richland, WA 99352

Dear Dennis:

Ken Burnham and I have looked through the draft report on the Friday Harbor workshop. Several suggested changes are given on the attached copy. These changes are fairly minor (affected pages are paperclipped). Generally, the report well reflects the workshop.

Our only reservation concerns Appendix A. which was actually done after the workshop. This section seems poorly done; it certainly does not follow the procedures suggested in the AFS monograph. Instead. only one group of fish were marked, leading to only a Jolly-Seber model. We suggest a treatment group and a control group, allowing a sequence of models to be assessed. Statistical testing would lead to an adequate model, and estimates would be based on the model's assumptions. The material in Appendix A does not reflect what is recommended in Burnham et al. (1987).

Two groups of marked fish allow the estimation of a survival rate for each group, ϕ_t and ϕ_c. The treatment effect S is the ratio of the group-specific survival rates. This ratio is considerably more robust to the violation of assumptions that are the individual rates. Appendix A is not particularly adequate.

In addition, we note the statement. "This exercise illustrates how the effect of model assumption violations can be studied with a mechanistic model." However. the standard error is large and the 95% confidence interval easily includes the true parameter from the fishpass model. Thus, no model bias is illustrated.

We are not saying that the theory in the AFS book always gives good estimates in practical situations. However, the exercise mentioned in Appendix A is not very useful and may be fairly misleading. Also, since is was done after the workshop, it even seems odd to include this.

Appendix C is a worthwhile addition, allowing people to understand the meaning intended. The "epidemiological approach" is a somewhat poor term. It is the extension of existing theory (in this case, capture-recapture) to include group or individual covariates. or model parameters as functions of other variables. These is a growing literature on these extensions. This work should be developed further in the Columbia River setting. However, this does not represent either a new or alternative approach. Instead. it is an extension to what is now available.

Surely, the statement on page ix is some sort of gross word-processing typo?

I hope these comments will be helpful. We look forward to receiving copies of the final report. Thank you

Sincerely,

David R. Anderson

FAX to Dauble
509-376-9449

June 1, 1989

Dr. Dennis Dauble, P7-50
Battelle, PNL
P.O. Box 999
Richland, WA 99352

RE: Review Draft May 1989: Proceedings of the Smolt Survival Workshop, Friday Harbor, Washington, February 1-3, 1989

Dear Dennis;

I will be sending in comments along with other members of the fisheries agencies and tribes within the next two weeks. My comments which are written directly on the manuscript are too lengthy to incorporate in the combined comments, however they will be mailed on June 5, and should reach you during that week. It was not an easy job to put together the views of such a diverse group on a complex topic, so please accept my compliments on the completion of a tough job.

The opinions in this letter and my comments on the manuscript are intended to be constructive, and if they are occasionally blunt, I plead guilty to being intensely interested in the subject matter. The opinions expressed herein and on the manuscript do not represent the official positions of my employer, nor those of the other fisheries agencies and tribes.

In addition to the comments written on the manuscript, I have further concerns about the lack of attribution of concepts and opinions to the editors and to the participants. The cover page doesn't identify Anderson, Dauble and Neitzel as authors, facilitators, editors, or whatever. The second paragraph of the FOREWORD states, "The results of the workshop presented herein, represent the advice of the participants to BPA on how to proceed with the next steps in survival studies." This is followed directly by the executive summary with a stated goal (p. v) of "Identify consensus of future directions for survival studies.". There follow a number of statements of questionable precision and accuracy regarding the need for survival studies (p. vi), the relative uncertainty in estimates of survival based from program RELEASE and "reservoir and reach survival studies" (p. vi), a vague statement about the possibility of testing "flow/survival relationships" using "allocated flows" from the water budget (p. vii) and a qualitative judgement of how most individuals at the workshop felt about survival estimates.

I recommend you delete all of the language starting with the last paragraph on p. v through the end of p. ix. This could readily be replaced by the language of p. 67, which is far shorter and more accurate.

I further recommend you delete the introduction starting on page 3 up to the SCOPING SESSION section.

Combine the remaining language of the introduction on p. 5-6 with the remaining language from p. v, and this would make a good introduction.

I have some general concerns to share with you about the conduct of this workshop with some recommendations for future workshops. The workshop process has a lot potential to contribute positively to shaping scientific ideas, and in building the consensus necessary to implement large scale, expensive studies. In order to be more effective,

notes should be prepared and reviewed during the workshop with the active involvement of participants. Portable microcomputers work very well for this purpose.

Individual opinions should be attributed to the person who made them, and group consensus should be so noted. In an area of study which is so controversial, the longer the time lag between discussion and review of the notes, the greater the certainty of acrimonious disagreements over who said what, to whom, and when.

Within an hour of the end of each session, each participant should have a spell-checked version of their portion of the proceedings for review.

Contributed papers should be collected in advance of the workshop, in draft if necessary, and distributed to all participants on arrival.

A large portion of the "work" in workshop should be the production of a precise and rigorous record of the proceedings. Lack of precision with respect to the source of recommendations will always detract from the utility of this workshop proceedings.

The negative impact of the lack of precision has been compounded by the citing of "the workshop" as an authoritative scientific source by some participants during the 14 weeks which elapsed between the end of the workshop and the mailing of the first full draft to participants for review. During that time it was impossible to deal objectively with claims based on workshop activities without a manuscript, and now that we have a manuscript, it isn't possible to tell who, or how many, said what. Thus an opportunity to build consensus, or at least take stock of minority and majority opinions, has been lost, in my opinion.

Sincerely, Phil Mundy

503-238-0667

cc: Pat Poe

COLUMBIA RIVER INTER-TRIBAL FISH COMMISSION
975 S.E. Sandy Boulevard Suite 202, Portland, Oregon 97214
Telephone (503) 238-0667
Fax (503) 235-4228

August 14, 1989

Dr. Dennis Dauble, P7-50
Battelle, PNL
P.O. Box 999
Richland, WA 99352

RE: Request for Letterhead Version of June 1, 1989 on the Review Draft May 1989: Proceedings of the Smolt Survival Workshop, Friday Harbor, Washington, February l-3, 1989

Dear Dr. Dauble:

Most of my comments on the subject manuscript are written directly on my copy of the manuscript which was mailed to you on June 5. I realize it was not an easy job for anyone to put together the views of such a diverse group on a complex topic, so please accept my compliments on the completion of a tough job.

In addition to the comments written on the manuscript, I have further concerns about the lack of attribution of concepts and opinions to the editors and to the participants. The cover page doesn't identify the relation of Messrs. Anderson, Dauble, and Neitzel to the manuscript. The second paragraph of the FOREWORD states, "The results of the workshop presented herein, represent the advice of the participants to BPA on how to proceed with the next steps in survival studies." This is followed directly by the executive summary with a stated goal (p. v) of "Identify consensus of future directions for survival studies." There follow a number of statements of questionable precision and accuracy. regarding the need for survival studies (p. vi), the relative uncertainty in estimates of survival based from program RELEASE and "reservoir and reach survival studies" (p. vi), a vague statement about the possibility of testing "flow/survival relationships" using "allocated flows" from the water budget (p. vii) and a qualitative judgement of how most individuals at the workshop felt about survival estimates.

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I have some general concerns to share with you about the conduct of this workshop with some recommendations for future workshops. The workshop process has a lot of potential to contribute positively to shaping scientific ideas, and in building the consensus necessary to implement large scale, expensive studies. In order to be more effective:

Notes should be prepared and reviewed during the workshop with the active involvement of. participants. Portable microcomputers work very well for this purpose.

Individual opinions should be attributed to the person who made them, and group consensus should be so noted. In an area of study which is so controversial, the longer the time lag between discussion and review of the notes, the greater the certainty of acrimonious disagreements over who said what, to whom, and when.

Within an hour of the end of each session, each participant should have a spell-checked version of their portion of the proceedings for review.

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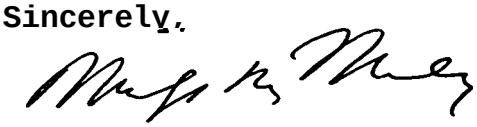
The negative impact of the lack of precision has been compounded by the citing of "the workshop" as an authoritative scientific source by some participants during the 14 weeks which elapsed between the end of the workshop and the mailing of the first full draft to participants for review. During that time it was impossible to deal objectively with claims based on workshop activities without a manuscript, and now that we have a manuscript, it isn't possible to tell who, or how many, said what. Thus an opportunity to build consensus, or at least take stock of minority and majority opinions, has been lost, in my opinion.

Please be assured that these comments are intended to be constructive. It is my hope that they will help you produce a better manuscript, and to conduct even better workshops in the future.

Sincerely,



Phillip R. Mundy, Ph.D.
Senior Research Scientist

cc: Pat Poe, BPA, Fish and Wildlife, Portland

NEIL GOLDSCHMIDT
GOVERNOR

Department of Fish and Wildlife

506 SW MILL STREET, P.O. BOX 59, PORTLAND, OREGON 97207

July 5, 1989

Dr. Dennis Dauble
Batetelle, Pacific Northwest Laboratories
PO Box 999
Richland, WA 99352

Dear Dr. Dauble:

Frank Young, Tony Nigro, and myself attended the Smolt Survival Workshop in February 1989 and submit the following comments on the draft proceedings as requested.

The draft accurately reflects the agenda items presented on day one of the workshop regarding the importance of survival studies and review of survival estimation techniques. I also found that the draft proceedings of the Standards Group which I attended on day two was accurate.

However, Tony Nigro, who attended the Model Group on day two does not recall the group making the recommendation "Studies should be initiated to determine if a multivariate analysis has use in evaluating the water budget effectiveness." In fact, there was a general consensus that such an effort would be futile because of the low probability of detecting small increments in flow resulting from the Water Budget. In addition, Frank Young, who attended the Future Direction Group, does not agree with the statement made that "Individuals agreed that valid survival estimates were needed to improve parameter estimation and modeling efforts and to evaluate the effectiveness of the Council's Fish and Wildlife Program... including the water budget, bypass options, reservoir management (predator control), hatchery effectiveness, and transportation." He recalls that statements were made that specific needs for survival or improved survival estimation were ill defined at this time and would be developed by the appropriate Authority, Council, or Corps research technical committees. Because of these ill defined needs, Frank does not recall that he supported the recommendation "There is a need to proceed with model evaluation before survival estimates can be

improved." and that "This evaluation should include the three current/proposed models or approaches for determining fish survival, i.e. direct, release/capture (indirect), and epidemiology."

Neither Tony, Frank, or myself attended the wrap-up session on day three. I understand that the agencies and tribes were poorly represented. The three major recommendations made in the wrap-up session do not follow recommendations made during the first two days of the workshop when all participants were present. As such, in order to not give the impression that these recommendations were developed and supported by all workshop participants, you need-identify who was present at the wrap-up session and make it clear that the recommendations are solely theirs.

I will answer any questions you might have on our comments at (503)229-5675.

Sincerely,

Raymond R. Boyce

Raymond R. Boyce
Fish Division

c: Young, Nigro
FPAC
Pat Poe (BPA)